

The Invention of the Counterweight Trebuchet: A Study in Cultural Diffusion

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The counterweight trebuchet represents the first significant mechanical utilization of gravitational energy. In the military realm, this artillery weapon played a significant role in warfare across Eurasia and North Africa. It unleashed a revolution in siegecraft and provided the impulse for dramatic changes in military architecture to counter the greater destructive force of gravity-powered artillery. In the political realm, the emergence of the centralized state owes something to this machine, according to Joseph Needham and Robin Yates, due to the increased resource mobilization by the state that the new technology necessitated. In the field of technology, it influenced the development of such practical devices as clockwork, as Lynn White has demonstrated. According to White, this weapon may even have affected the evolution of pure science during the Middle Ages. This subject has been taken up by Vernard Foley, who has argued that the counterweight trebuchet played a role in the greatest single advance in physical science of the medieval period, the innovations in theoretical mechanics associated with Jordanus of Nemore.¹

The counterweight trebuchet was the product of a technological tradition that began in ancient China, was further advanced in the technologically sophisticated civilizations of Islam and Byzantium, and was brought to its fullest development in Western Europe. This machine was a collective achievement of four civilizations and stands as one of the greatest products of multiculturalism in the field of technology. The development of the counterweight trebuchet dramatically illustrates technological adaptation

¹P. E. Chevedden, "Fortifications and the Development of Defensive Planning during the Crusader Period," in *The Circle of War in the Middle Ages*, ed. D. J. Kagay and L. J. A. Villalon (Woodbridge, Suffolk, 1999), 33–43; J. Needham and R. D. S. Yates, *Science and Civilisation in China*, vol. 5, *Chemistry and Chemical Technology*, pt. 6, *Military Technology: Missiles and Sieges* (Cambridge, 1994), 239–41; L. White, Jr., *Medieval Technology and Social Change* (Oxford, 1962), 103; idem, *Medieval Religion and Technology* (Berkeley, 1978), 14, 54, 88–89, 238, 268, 269, 283–85, 308; P. E. Chevedden, L. Eigenbrod, V. Foley, and W. Soedel, "The Trebuchet: Recent Reconstructions and Computer Simulations Reveal the Operating Principles of the Most Powerful Weapon of Its Time," *Scientific American* (July 1995): 66–71. Research on this article has been supported by a grant from the National Endowment for the Humanities. I would like to thank Robert I. Burns, S. J., George T. Dennis, S. J., Les Eigenbrod, Vernard Foley, Donald J. Kagay, Werner Soedel, Sarolta A. Takacs, and Theresa M. Vann for their discussion on the topics considered in this paper. I also thank the Thesaurus Linguae Graecae at the University of California, Irvine, for running searches for Greek terms pertaining to artillery.

spurred by the dynamics of conflict and contact over the wide expanse of Eurasia and North Africa.

The counterweight trebuchet left its mark on warfare, political institutions, technology, and on pure science, yet its origins and early development remain obscure. Current scholarship has advanced little beyond the conclusions reached more than a century ago. It has been assumed that the machine came into use around 1200 and shortly afterwards developed amazing capabilities.² In the sketchbook of Villard de Honnecourt produced between 1220 and 1240, a gravity-powered trebuchet is depicted that utilized a counterweight box with a volume of about eighteen cubic meters. This box, according to a recent study, could have carried a mass weighing up to thirty tons. It has been estimated that a trebuchet with a mass of this capacity could launch a 100-kilogram projectile more than 400 meters and a 250-kilogram projectile more than 160 meters. With a mass half this weight, a projectile of 100 kilograms could be flung 217 meters and one of 60 kilograms hurled 365 meters. Such a high level of performance would have been astounding if it were achieved only a few decades after the introduction of the counterweight trebuchet. Rapid development of this kind strains credulity.³

²For a discussion of the historical development of the trebuchet, see G. Dufour, *Mémoire sur l'artillerie des anciens et sur celle du Moyen Age* (Paris, 1840), 87–112; L.-N. Bonaparte, *Études sur le passé et l'avenir de l'artillerie*, 6 vols. (Paris, 1848–71), 2:26–61; E. E. Viollet-le-Duc, *Dictionnaire raisonné de l'architecture du XIe au XVIe siècles*, 10 vols. (Paris, 1854–68), 5:218–42; G. Köhler, *Die Entwicklung des Kriegswesens und der Kriegführung in der Ritterzeit von Mitte des II. Jahrhunderts bis zu den Hussitenkriegen* (Breslau, 1890), 3:139–211; R. Schneider, *Die Artillerie des Mittelalters* (Berlin, 1910); H. Yule, ed., *The Book of Ser Marco Polo, the Venetian Concerning the Kingdoms and Marvels of the East*, 3d ed., 3 vols. (London, 1926), 2:161–69; B. Rathgen, *Das Geschütz im Mittelalter* (Berlin, 1928; repr. Düsseldorf, 1987), 578–638; K. Huuri, “Zur Geschichte des mittelalterlichen Geschützwesens aus orientalischen Quellen,” *StOr* 9.3 (Helsinki, 1941); White, *Medieval Technology and Social Change*, 102–3, 165; J.-F. Finó, “Machines de jet médiévales,” *Gladius* 10 (1972): 25–43; idem, *Forteresses de la France médiévale: construction, attaque, défense*, 3d ed. (Paris, 1977), 149–63; D. R. Hill, “Trebuchets,” *Viator* 4 (1973): 99–115; J. Needham, “China’s Trebuchets, Manned and Counterweighted,” in *On Pre-Modern Technology and Science. Studies in Honor of Lynn White, Jr.*, ed. B. S. Hall and D. C. West (Malibu, 1976), 107–45; S. A. Shkoliar, “L’Artillerie de jet à l’époque Sung,” *Études Song*, ser. 1, *Histoire et institutions*, pt. 2, ed. F. Aubin (Paris, 1971), 119–42; idem, *Kitaikaia doognestrel’naia artilleriia: materialy i issledovaniia* (Moscow, 1980); C. M. Gillmor, “The Introduction of the Traction Trebuchet into the Latin West,” *Viator* 12 (1981): 1–8; D. J. C. King, “The Trebuchet and Other Siege-Engines,” *Chateau Gaillard* 9–10 (1982): 457–69; R. D. S. Yates, “Siege Engines and Late Zhou Military Technology,” in *Explorations in the History of Science and Technology in China*, ed. Li Guohao, Zhang Mehgwen, and Cao Tianqin (Shanghai, 1982), 414–19; R. Rogers, “The Problem of Artillery,” App. 3 of *Latin Siege Warfare in the Twelfth Century* (Oxford, 1992), 254–73; Needham and Yates, *Science and Civilisation in China*; Chevedden et al., “The Trebuchet”; P. E. Chevedden, “The Artillery of King James I the Conqueror,” in *Iberia and the Mediterranean World of the Middle Ages. Essays in Honor of Robert I. Burns*, S. J., ed. P. E. Chevedden, D. J. Kagay, and P. G. Padilla (Leiden, 1996), 179–222; idem, “The Hybrid Trebuchet: The Halfway Step to the Counterweight Trebuchet,” in *On the Social Origins of Medieval Institutions. Essays in Honor of Joseph F. O’Callaghan*, ed. D. J. Kagay and T. M. Vann (Leiden, 1998), 179–222; P. E. Chevedden, Z. Shiller, S. R. Gilbert, and D. J. Kagay, “The Traction Trebuchet: A Triumph of Four Civilizations,” *Viator* 31 (2000): 433–86.

³Villard de Honnecourt, *Album de Villard de Honnecourt, Architecte du XIIIe siècle*, ed. J. B. A. Lassus and A. Darcel (Paris, 1858); idem, *Facsimile of the Sketch-Book of Wilars de Honecourt, An Architect of the Thirteenth Century*, with comments and descriptions by J. B. A. Lassus and J. Quicherat, trans. and ed. R. Willis (London, 1859); idem, *Villard de Honnecourt: Kritisch Gesamtausgabe des Bauhüttenbüches ms. Fr 19093 der Pariser Nationalbibliothek*, ed. H. R. Hahnloser (Vienna, 1935); idem, *Carnet de Villard de Honnecourt d’après le manuscrit conservé à la Bibliothèque nationale de Paris (no. 19093)*, ed. A. Erlande-Brandenburg et al. (Paris, 1986); Viollet-le-Duc, *Dictionnaire raisonné*, 5:218–42; R. Bechmann, *Villard de Honnecourt: La pensée technique au XIIIe siècle et sa communication* (Paris, 1991), 255–72.

It is now known that medieval fortifications and defensive planning began a process of revolutionary change shortly after 1200 in order to counter the greater destructive power of the counterweight trebuchet and to exploit this new artillery for use in the defense of strongpoints.⁴ It is unlikely that a transition in fortification design would have followed immediately after the first appearance of the counterweight trebuchet. After all, the bastion system of defensive planning used in the sixteenth century, which arose out of a need to withstand the devastating blows of even more effective gunpowder artillery, did not emerge until well after the introduction of efficient cannon.⁵ One would expect the counterweight trebuchet to have undergone a process of development before defensive planners were required to come up with positive countermeasures to thwart it. Hence, an earlier dating for the introduction of the counterweight trebuchet appears likely. Before examining the historical evidence on this question, a brief introduction to the trebuchet is in order.

HURLING MOUNTAINS AND HILLS

By the end of the sixth century, a new class of artillery had replaced the stone-projectors of classical antiquity.⁶ This class of artillery, conventionally denoted by the

⁴On the changes in military architecture resulting from the introduction of the counterweight trebuchet, see P. E. Chevedden, "The Citadel of Damascus" (Ph.D. diss., University of California, Los Angeles, 1986); idem, "Fortifications and the Development of Defensive Planning." Clive Foss and David Winfield suggest that Byzantine military architecture underwent changes during the reign of Manuel I Komnenos (1143–80) to counteract the counterweight trebuchet: C. Foss, *Survey of Medieval Castles of Anatolia*, vol. 1, *Kütahya* (Oxford, 1985), 77, 83; C. Foss and D. Winfield, *Byzantine Fortifications: An Introduction* (Pretoria, 1986), 48. For alternate views regarding the dating and purpose of some of the changes in military architecture noted by Foss and Winfield, see R. W. Edwards, review of C. Foss, *Survey of Medieval Castles of Anatolia*, *Speculum* 62.3 (1987): 675–80; Chevedden, "Fortifications and the Development of Defensive Planning."

⁵On the new system of fortifications of the gunpowder era, see J. R. Hall, "The Early Development of the Bastion: An Italian Chronology, c. 1450–c. 1534," in *Europe in the Late Middle Ages*, ed. J. R. Hale, L. Highfield, and B. Smalley (London, 1965), 466–94; C. Duffy, *Siege Warfare: The Fortress in the Early Modern World, 1494–1660* (London, 1979); S. Peper and N. Adams, *Firearms and Fortifications: Military Architecture and Siege Warfare in Sixteenth-Century Siena* (Chicago, 1986).

⁶On the artillery of classical antiquity, see E. Schramm, *Die Antiken Geschütze de Saalburg* (1918; repr. Bad Homburg, 1980); E. W. Marsden, *Greek and Roman Artillery: Historical Development* (Oxford, 1969); idem, *Greek and Roman Artillery: Technical Treatises* (Oxford, 1971); N. Gudea and D. Baatz, "Teile Spätromischer Ballisten aus Gornea und Orsova (Rumänien)," *Saalburg Jahrbuch* 31 (1974): 50–72; D. Baatz, "The Hatra Ballista," *Sumer* 33.1 (1977): 141–51; idem, "Das Torsionsgeschütz von Hatra," *Antike Welt* 9.4 (1978): 50–57; idem, "Recent Finds of Ancient Artillery," *Britannia* 9 (1978): 1–17, pls. 1–5; idem, "Teile Hellenistischer Geschütze aus Griechenland," *AA* (1979): 68–75; idem, "Ein Katapult der Legio IV Macedonica aus Cremona," *Römische Mitteilungen* 87 (1980): 283–99; idem, "Hellenistische Katapulte aus Ephyra (Epirus)," *Athenische Mitteilungen* 97 (1982): 211–33; idem, "Katapultteile aus dem Schiffswrack von Mahdia (Tunesien)," *AA* (1985): 677–91; idem, "Eine Katapult-Spannbuchse aus Pityus, Georgien (UDSSR)," *Saalburg Jahrbuch* 44 (1988): 63–64; idem, "Die Römische Jagdarmbrust," *Archäologisches Korrespondenzblatt* 21 (1991): 283–90; idem, *Bauten und Katapulte des römischen Heeres* (Stuttgart, 1994); D. Baatz and M. Feugère, "Éléments d'une catapulte romaine trouvée à Lyon," *Gallia* 39 (1981): 201–9; A. G. Drachmann, *The Mechanical Technology of Greek and Roman Antiquity* (Copenhagen, 1963), 186–91; idem, "Biton and the Development of the Catapult," in *Prismata, Naturwissenschaftsgeschichtliche Studien. Festschrift für Willy Hartner*, ed. Y. Maeyama and W. G. Saltzer (Wiesbaden, 1977), 119–31; B. C. Hacker, "Greek Catapults and Catapult Technology: Science, Technology and War in the Ancient World," *Technology and Culture* 9 (1968): 34–50; Y. Garlan, *Recherches de poliorcétique grecque* (Athens, 1974), 212–25; J. G. Landels, *Engineering in the Ancient World* (Berkeley, 1978), 99–132; A. W. Lawrence, *Greek Aims in Fortifications* (Oxford, 1979), 43–49; W. Soedel and V. Foley, "Ancient Catapults," *Scientific American* 240 (March 1979): 150–60; P. Fleury, "Vitruve et la nomenclature des machines de jet romaines,"

French term *trebuchet*, consisted of a beam that pivoted around an axle that divided the beam into a long and short arm. At the end of the longer arm was a sling for hurling the missile, and at the end of the shorter one pulling ropes were attached, or, in later versions, a counterweight. To launch a projectile, the short arm, positioned aloft, was pulled downward by traction or gravity or by a combination of both forces. The impetus applied to the beam propelled the throwing arm of the machine upward and caused the missile to be hurled from the sling (Figs. 1–5).

Three distinct forms of this artillery developed: the traction trebuchet, powered by crews pulling on ropes; the hybrid trebuchet, powered by both a pulling-crew and gravity power; and the counterweight trebuchet, activated solely by the force of gravity obtained by the fall of a large pivoting mass. The traction trebuchet, invented by the Chinese sometime before the fourth century B.C., was partially superseded at the beginning of the eighth century by the hybrid trebuchet. This machine appears to have originated in the realms of Islam under the impetus of the Islamic conquest movements. By the ninth century, the hybrid trebuchet was being used in the Middle East and the Mediterranean world, as well as in northern Europe. The introduction of the counterweight trebuchet marked a breakthrough in the development of mechanical artillery. It was the first fully mechanized pivoting-beam artillery weapon powered exclusively by the force of gravity.

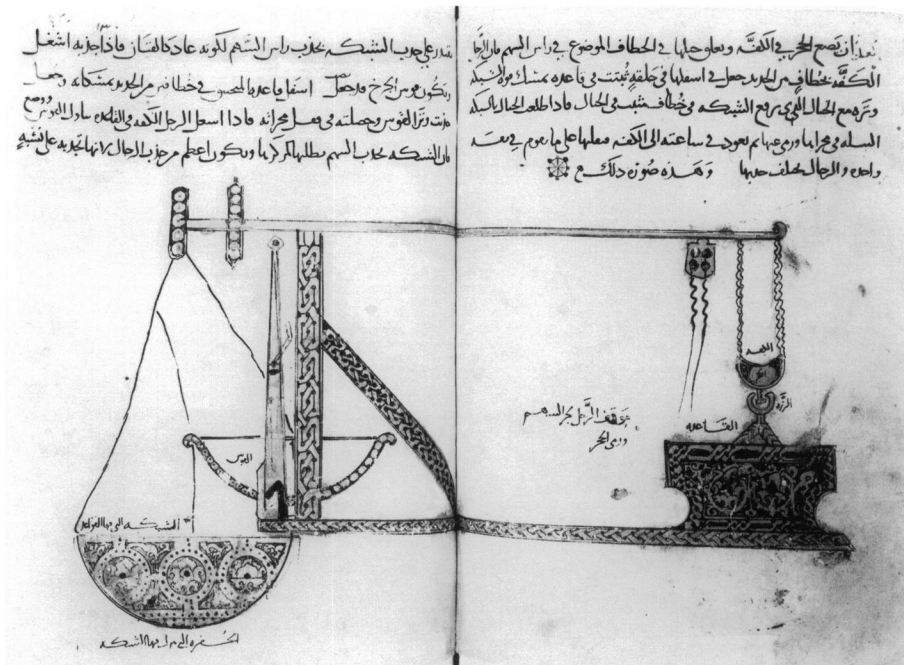
The elaboration of the trebuchet in its three forms increased the destructive power of mechanical artillery considerably. The most powerful Chinese traction trebuchet with a 250-man pulling-crew was capable of throwing a stone-shot weighing between 57 and 63 kilograms a distance of more than 75 meters.⁷ The *Miracula of St. Demetrius* written by John I, archbishop of Thessalonike, is the first historical work to provide a detailed description of the traction trebuchet. The Avaro-Slavs employed a battery of fifty traction trebuchets (πετροβόλοι, *petroboloi*) when they laid siege to Thessalonike in 597, and the archbishop of the city graphically details the devastation wrought by them:

These trebuchets [*petroboloi*] had quadrilateral [trusses] that were wider at the base and became progressively narrower toward the top. Attached to these machines were thick axles plated with iron at the ends, and there were nailed to them pieces of timber like beams of a large house. Hanging from the back side of these pieces of timber were slings and from the front strong ropes, by which, pulling down and releasing the sling, they propel the stones up high and with a loud noise. And on being discharged they sent up many great stones so that neither earth nor human constructions could withstand the impacts. They also covered those quadrilateral-shaped trebuchets [*petroboloi*] with planks on three sides, so that those inside launching them might not be wounded by arrows [shot] by those on the city walls. And since one of these, with its planks, had been consumed by fire from an incendiary arrow, they returned, carrying off the machines. On the following day they again brought up these trebuchets [*petroboloi*] covered with freshly skinned hides and planks, and placing them closer to the city walls, shooting, they hurled mountains and hills against us. For what else might one term these immensely large stones?⁸

REL 59 (1981): 216–34; P. E. Chevedden, “Artillery in Late Antiquity: Prelude to the Middle Ages,” in *The Medieval City under Siege*, ed. I. Corfis and M. Wolfe (Woodbridge, Suffolk, 1995), 131–73; A. Wilkins, “Reconstructing the *Cheiroballistra*,” *Journal of Roman Military Equipment Studies* 6 (1995): 5–59.

⁷This quantitative data is taken from the Chinese military treatise, *Wu jing zong yao* (The essentials of the military classics), completed in 1044. For this important data, Shkoliar, *Kitaiskaia doognestrel'naia artilleriia*, 358–69; and Chevedden et al., “Traction Trebuchet,” table 3.

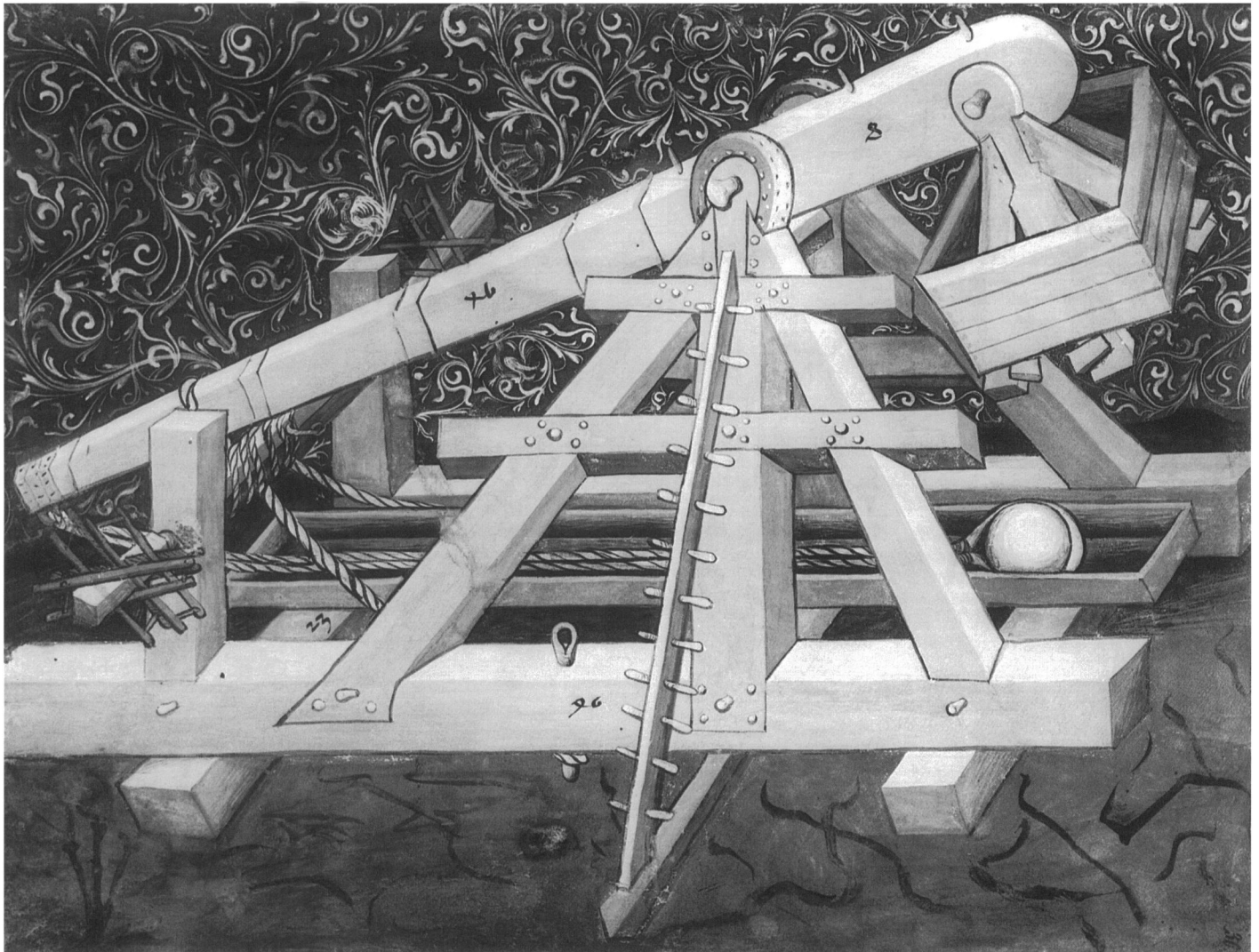
⁸John I, archbishop of Thessalonike, *Miracula S. Demetrii*, ed. P. Lemerle, *Les plus anciens recueils des miracles de saint Démétrius et la pénétration des slaves dans les Balkans*, 2 vols. (Paris, 1979), 1:154. The rendering of this



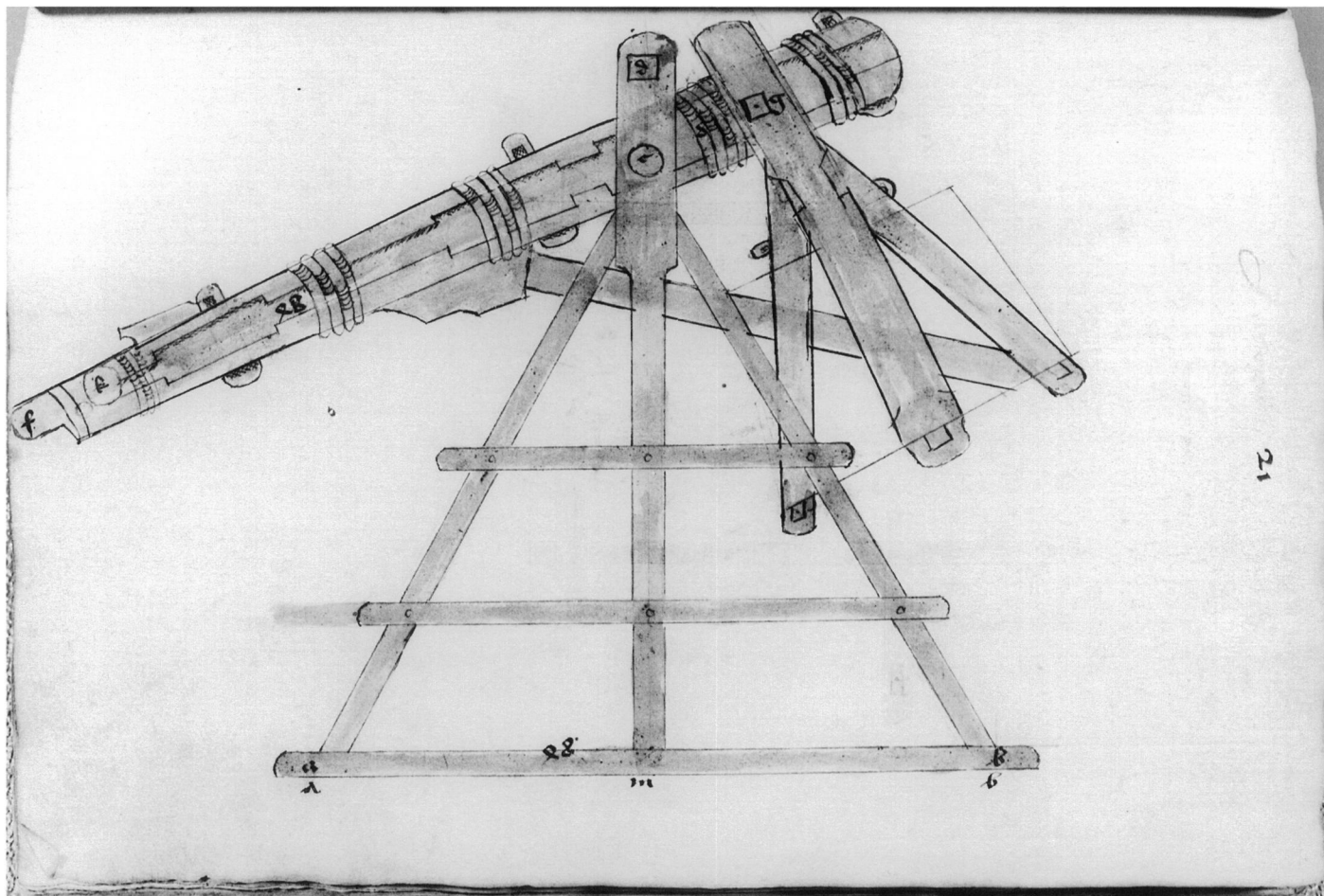
- 1 Tarsūsī, *Tabṣīrah fi al-ḥurūb*, Oxford, Bodleian, MS Hunt. 264, fols. 134v–135r. Tarsūsī's counterweight trebuchet, the earliest extant illustration of a gravity-powered trebuchet, dating from ca. 1187. This machine, operated by a single man, served two functions: it was a medium-size trebuchet, having the throwing power of a “fifty-man” traction machine, and it functioned as a spanning device for a large siege crossbow, shown on the left. Captions read: *left (top to bottom)*, “the bow”; “the net which has in it bases [sic]” [stones]; “the hole in which the net [the counterweight] descends”; *center*, “the position of the man for hauling down the beam and shooting the stone”; *right (top to bottom)*, “the pouch”; “the stone”; “the U-bolt”; “the base.”



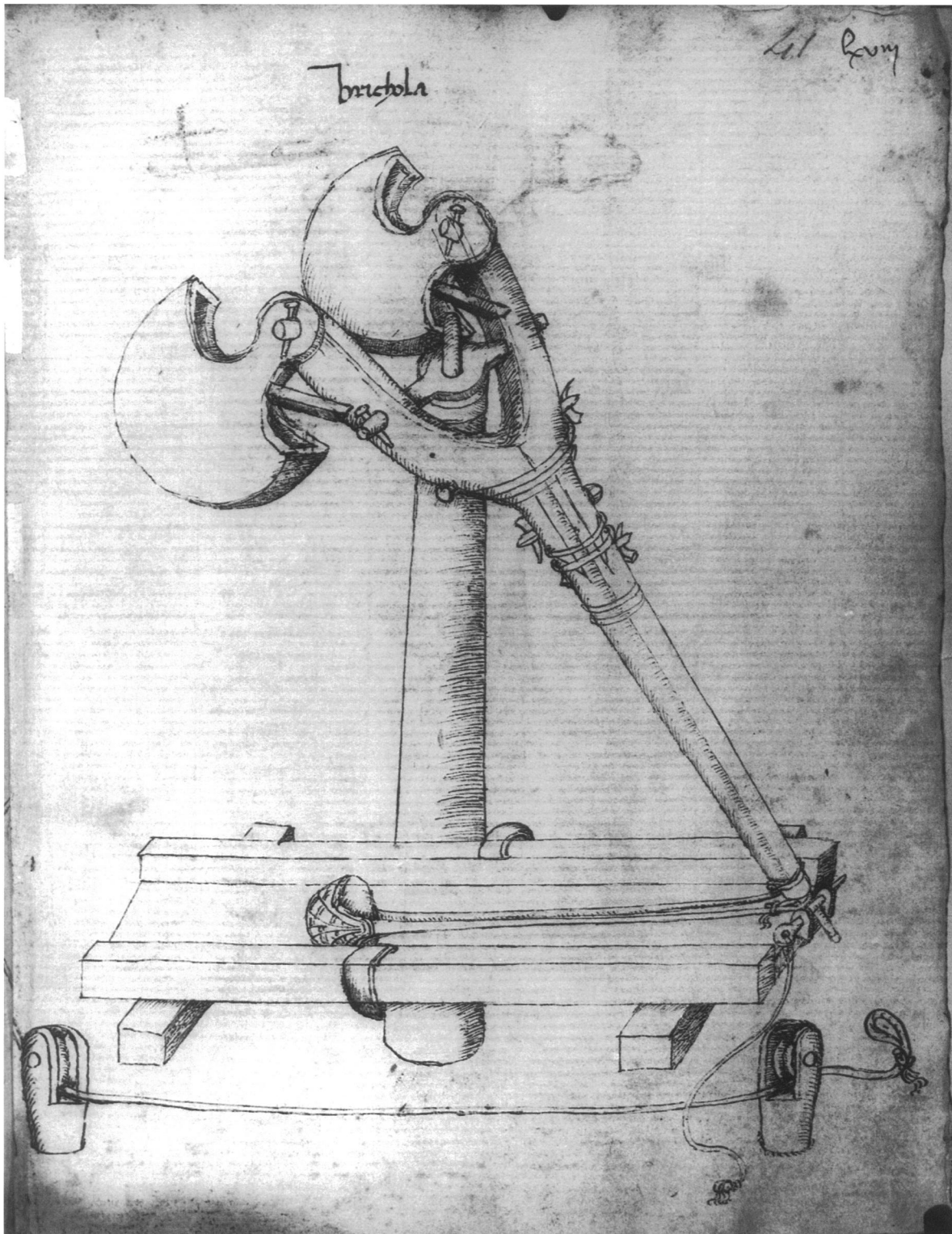
- 2 Rashīd al-Dīn, *Jāmi' al-tawārīkh* (1306–1307), Edinburgh, Edinburgh University Library, MS Arab 20, fol. 130v. The army of Maḥmūd ibn Sebuktegin captures the fortress of Muḥammad ibn Abū Naṣr Muḥammad in 1012. The operator of the counterweight trebuchet—depicted in Arab or Persian attire—is about to discharge the machine by striking a blow to the pin holding down the beam with his mallet. Bolts and metal plates create strong and effective joints on the framework of the machine and on the box holding the counterweight.



- 3 Conrad Kyaser of Eichstätt, *Bellifortis* (ca. 1405), Göttingen, Niedersächsische Staats- und Universitätsbibliothek, Cod. MS philos. 63, fol. 30r. A large counterweight trebuchet. The main beam, counterweight box, sling, projectile, trough, windlass, and framework are all clearly visible with dimensions given for some of the component parts. The main beam measures 54 “workfeet,” or 15.55 m, with a throwing arm of 46 “workfeet,” or 13.248 m. The distance from the axle of the beam to the axle of the hinged counterweight box is 8 “workfeet,” or 2.304 m, dividing the beam in the ratio 5.75:1. A ratio of 6:1 is designated for the beam of a trebuchet in the Innsbruck manuscript of *Bellifortis* (Fig. 4), indicating that the dimensions given here may have been miscalculated. The trestle frame is composed of two linked supporting trusses, each forming an equilateral triangle with base and sides measuring 46 “workfeet,” or 13.248 m. The main axle is placed at the apex of the trusses 11.47 m above the ground. The main beam is banded by metal plates to withstand splitting, and the trusses of the framework are reinforced by horizontal braces that are bolted to the structure. The prong at the end of the long arm, which is essential for the release of the sling, is not depicted. Instead, both cords of the sling are incorrectly shown as being attached to a ring at the extremity of the long arm. This massive machine used a simple peg-and-hole, catch-and-trigger device to retain and release the beam. A hole drilled in the base of one of the trusses of the machine contains the peg. A restraining rope, attached to the base of the other truss is drawn over the long arm of the beam at a point just above the windlass and is looped over the bottom end of the peg. When the peg is lifted out of its socket, the looped end of the rope is released, and the beam flies free. This type of machine was identified in Arabic historical sources as the Western Islamic trebuchet (*manjanīq maghribī*) and in Byzantine sources as the *helepolis* (city taker).



- 4 Conrad Kyeser of Eichstätt, *Bellifortis*, Innsbruck, Tiroler Landesmuseum Ferdinandeum, MS 16.0.7, fol. 21r. A large counterweight trebuchet noticeably different from its counterpart in the Göttingen manuscript of *Bellifortis* (Fig. 3). The main beam, counterweight box, and trestle framework are clearly shown with some components dimensioned. The main beam measures 56 “workfeet,” or 16.12 m, with a throwing arm of 48 “workfeet,” or 13.82 m. The distance from the axle of the beam to the axle of the hinged counterweight box is 8 “workfeet,” or 2.30 m, dividing the beam in the ratio 6:1. The trestle frame is composed of two linked supporting trusses, each forming an equilateral triangle with base and sides measuring 48 “workfeet,” or 13.82 m. The main axle is placed at the apex of the trusses 11.97 m above the ground. The rounded beam is composed of three spars of wood that are banded by rope and reinforced by three giant wooden pegs. A large strut is used to prop the counterweight box, and the truss of the framework is reinforced by horizontal braces that are bolted to the structure. The dimensions provided for this trebuchet revise some of the measurements given for the machine in the Göttingen manuscript of *Bellifortis* (Fig. 3). The measurement for the throwing arm in this illustration was originally written as “46,” corresponding to the figure given in the Göttingen manuscript, and was then changed to “48.” The draftsman realized that the dimensions for the machine in the Göttingen manuscript would not divide the beam in the ratio 6:1 and made the necessary corrections.



- 5 Mariano di Jacopo Taccola, *Liber Tertius de ingeneis ac edifiitiis non usitatis* (1433), Florence, Biblioteca Nazionale Centrale, Cod. palat. 766, fol. 41r. The “brichola” (*bricola*), a pole-framed trebuchet with two hinged counterweights. This machine was identified in Arabic historical sources as the Frankish or European trebuchet (*manjanīq firanjī/īfranjī*). In Byzantium, the *bricola* was designated by the Latin loan word *praikoula* or *prekoula*.

How and when did the Avaro-Slavs acquire the use of the traction trebuchet? These people did not possess the technology of mechanized siegecraft when they first appeared in the Balkans in the sixth century. Theophylactus Simocatta, the historian for the reign of Maurice (582–602), tells us that they first obtained this technology through a captured Byzantine soldier named Bousas. In exchange for his life, Bousas constructed for the Avaro-Slavs a missile-throwing siege machine referred to as a *helepolis* (ἐλέπολις, city-taker), which was instrumental in capturing the fortress of Appiaria in Moesia Inferior (in northern Bulgaria) in 587. Theophylactus states that:

Bousas taught the Avars to construct a certain siege machine, for they [the Avars] happened to be most ignorant of such machines, and he built the trebuchet [*helepolis*] to hurl missiles. Soon thereafter the fortress was leveled, and Bousas collected judgment for their inhumanity, having taught the barbarians something frightful, the technology of besieging. Thence the enemy captured effortlessly a great many of the Roman cities by making use of this original device.⁹

The machine that leveled the fortress of Appiaria in 587 is most certainly the same machine that “hurled mountains and hills” against Thessalonike in 597. The term *helepolis*, therefore, corresponds to *petrobolos* (πετροβολος) and refers to the traction trebuchet, which the Avaro-Slavs first acquired from the Byzantines in 587. Hence, we can assume that the Byzantines were making full use of the traction trebuchet prior to this date and place the introduction of this machine into the Mediterranean region at least as far back as the sixth century.

The stone-projector that was capable of leveling fortresses and hurling mountains and hills was partially superseded, in the eighth century, by an even mightier piece of artillery: the hybrid trebuchet. This ordnance was far more powerful than its progenitor, and it easily outstripped the artillery of the classical world. In 1218, crusaders besieging Damietta in the Nile delta utilized a hybrid trebuchet that launched stone-shot weighing 185 kilograms, six times as heavy as that of the most commonly used large ancient catapults.¹⁰ Counterweight trebuchets could do much more. Their projectiles probably reached a common maximum of 300 kilograms, and during the fourteenth century there

passage on the artillery used by the Avaro-Slavs at Thessalonike is based upon the translation by Speros Vryonis, Jr., in “The Evolution of Slavic Society and the Slavic Invasions in Greece: The First Major Slavic Attack on Thessaloniki, A.D. 597,” *Hesperia* 50 (1981): 384, but a number of changes have been made to indicate that the text describes trestle-framed traction trebuchets, not artillery of the classical world. Vryonis used the Latin word *ballistae* to translate the Greek term *petroboloi*, leaving the reader with the impression that these machines are tension or torsion catapults, rather than traction trebuchets. Lynn White, Jr., was the first scholar to draw attention to this passage as a description of a traction trebuchet (L. White, Jr., “Technology, Western,” *DMA* 11: 660). A scholarly debate still rages over the date of the Avaro-Slavic siege of Thessalonike during Maurice’s reign in the 6th century, with Lemerle, Yannopoulos, and Whitby arguing for 586 and Vryonis for 597. On this dating question, see Lemerle, *S. Démétrius*, 2:50–61; P. A. Yannopoulos, “La pénétration slave en Argolide,” *BCH*, suppl. 6 (1980): 323–71; M. Whitby, *The Emperor Maurice and His Historian: Theophylact Simocatta on Persian and Balkan Warfare* (Oxford, 1988), 117–21; Vryonis, “Evolution.”

⁹Theophylact Simocatta, *Historiae*, 2.16.10–11, ed. C. de Boor and P. Wirth (Stuttgart, 1972); translated in Vryonis, “Evolution,” 388, with the following change: the term *helepolis* (city-taker) is translated as “trebuchet,” not as “siege engine.” For another translation of this passage, less expertly rendered, see M. Whitby and M. Whitby, *The History of Theophylact Simocatta: An English Translation with Introduction and Notes* (Oxford, 1986), 66.

¹⁰Sāwirus Ibn al-Muqaffa’, Bishop of al-Ashmunayn, *History of the Patriarchs of the Egyptian Church*, ed. and trans. Y. ‘Abd al-Masīh, A. Sūryal Atiya, A. Khater, and O. H. E. Khs.-Burmester, 4 vols. (Cairo, 1942–74), 3.2:129 (Arabic text), 218 (trans.).

are reports of counterweight trebuchets that launched stones weighing between 900 and 1,200 kilograms.¹¹

The counterweight trebuchet was so far superior to any piece of artillery yet invented that its introduction brought about a revolution in siegecraft that rendered existing systems of defense obsolete. This gravity-powered siege-engine could discharge missiles of far greater weight than the traction or hybrid machines, and it could do so with remarkable accuracy. The machine was thus able to deliver devastating blows against the same spot of masonry time after time, and this made it potentially capable of demolishing the strongest fortified enclosures. The introduction of the counterweight trebuchet led to an increase in the scale of warfare and produced revolutionary changes in military architecture in order to counter the greater destructive power of this new artillery.

A THING WHICH AMAZED EVERYONE

The earliest reference to the counterweight trebuchet (*trabuchus*) that has been cited in a European historical source records its use at the siege of Castelnuovo Bocca d'Adda in northern Italy in 1199.¹² The earliest extant illustration of a counterweight trebuchet is found in a military manual written for Saladin around 583/1187 by Murḍī ibn 'Alī ibn Murḍī al-Ṭarsūsī.¹³ Relying principally on these two sources, most historians of artillery have concluded that the counterweight trebuchet was first introduced at the end of the twelfth century.¹⁴ Newly adduced historical evidence, however, suggests that the counterweight trebuchet can be traced as far back as the early twelfth century or perhaps earlier. Information previously dismissed or not taken into account indicates that attempts to produce a fully mechanized trebuchet powered exclusively by gravitational energy may have been underway by the end of the eleventh century.

The latter half of the eleventh century witnessed increased military activity in the eastern Mediterranean, as the Byzantine Empire, Western European crusaders, and the sultanate of the Great Seljuqs, joined by their dependents and local Atabeg dynasties, all contended for power. The upsurge in armed conflict in this region provided a great stimulus for the development of military technology, particularly artillery. At the first major military operation of the First Crusade—the siege of Nicaea (6 May to 19 June 1097)—there is conclusive evidence that new creative approaches were being attempted in the design of heavy artillery. Anna Komnene records that her father, the emperor Alexios I Komnenos (1081–1118), constructed large trebuchets, referred to as ἑλεπόλεις (*helepoleis*, city-takers), of several types, “and most of them were not fashioned according to conventional designs for such machines but followed ideas which he had devised himself and which amazed everyone.” Alexios supplied the crusaders with this artillery and with it they subjected Nicaea to a continuous bombardment of stone-shot.¹⁵

¹¹Huuri, “Geschützwesens,” 64.

¹²Ibid., 171.

¹³See below, note 63.

¹⁴In his study of Latin siege warfare in the 12th century, Rogers found no references to counterweight trebuchets. “Such weapons were in use in the early 1200s,” he concludes, “and thus it is likely that Latins developed or acquired the knowledge of this type of artillery during the later twelfth century” (R. Rogers, *Latin Siege Warfare in the Twelfth Century* [Oxford, 1992], 265).

¹⁵Anna Komnene, *Alexiade: Règne de l'empereur Alexis I Comnène (1081–1118)*, 11.2.1, 11.2.5, ed. and trans. B. Leib, 3 vols. (Paris, 1937–45) (this edition of Anna's chronicle is hereafter cited as AK). Two English

Not long after the siege of Nicaea, decisive evidence for the appearance of the counterweight trebuchet begins to appear in a variety of historical sources. The Byzantine historian, Niketas Choniates, offers very strong evidence for the existence of the counterweight trebuchet in his accounts of two sieges—Zevgminon in 1165 and Nicaea in 1184—by providing descriptive details of the machine (see below). An eye-witness account of the Norman siege of Thessalonike in 1185 speaks of “newly invented heavy artillery” being used and describes one monstrous trebuchet affectionately called “The Daughter of the Earthquake” and “Their Mother” (see below). Ṭarsūsī’s military manual presents the earliest full-length description and illustration of a counterweight trebuchet. Although this treatise was probably produced around 583/1187, the information contained in it on the counterweight trebuchet unquestionably dates from an earlier period (see below). The system of artillery nomenclature also provides persuasive evidence for the earlier existence of the counterweight trebuchet. Beginning in the second decade of the twelfth century, new terms are applied to pieces of heavy artillery in Syriac, Arabic, and Greek chronicles. Trebuchets are identified in these sources as “big,” “great,” “huge” or “frightful” machines (see below), indicating a change in technology: the introduction of the counterweight trebuchet. The building, deployment, and use of new types of heavy artillery at the siege of Nicaea in 1097 now takes on increased significance precisely because the counterweight trebuchet was about to make its debut.

But can we be sure that Emperor Alexios I was engaged in the development of the counterweight trebuchet? Historians examining Alexios’s inventive efforts during the siege of Nicaea in 1097 have been unable to ascertain what he was working on. Worse, his achievements in 1097 have been discredited. Anna’s account of her father’s construction of *helepoleis* and their role in the siege of Nicaea has been regarded as either highly misleading or false. In his military history of the First Crusade, John France misconstrues Anna’s account of Alexios’s *helepoleis* by claiming that the “machines” provided by the emperor to the crusaders were merely “designs for machines,” not actual weapons. He then rejects her account on the grounds that the crusader army “had considerable knowledge of siegecraft.”¹⁶ Randall Rogers proposes two possibilities regarding the emperor’s *helepoleis*: that either they played no part in the siege because they were probably never constructed, or, if they were constructed, they probably never reached Nicaea and so had no effect on the outcome of the siege. Ironically, both scholars credit Alexios with providing the crusaders with substantial support. France acknowledges that the emperor furnished “enormous” assistance, while Rogers assesses this aid as “considerable.” Both are adamant, however, that Byzantine assistance included no siege machines. Rogers concludes, “that crusader operations against Nicaea were organized and conducted within the expedition, and it seems that the siege engines involved in these efforts were built and operated by crusaders.” According to Rogers, the Byzantine contribution to the crusader siege-engines was limited to the supply of fastenings.¹⁷

translations of Anna Komnene’s chronicle can be consulted on the question of artillery at Nicaea: *The Alexiad of the Princess Anna Comnena*, trans. E. A. S. Dawes (London, 1928), 271–72 (hereafter AK [Dawes]), and *The Alexiad of Anna Comnena*, trans. E. R. A. Sewter (Harmondsworth, 1969), 336–37 (hereafter AK [Sewter]). A. Serper, “La prise de Nicée d’après la ‘Chanson d’Antioche’ de Richard le Pèlerin,” *Byzantion* 46 (1976): 411–21.

¹⁶J. France, *Victory in the East: A Military History of the First Crusade* (Cambridge, 1994), 162, 165, 368.

¹⁷Rogers, *Latin Siege Warfare*, 16–25.

France's arguments for dismissing Anna's account are fallacious. Anna's account clearly indicates that Alexios furnished the crusaders with actual machines, not designs for machines. Whether or not the crusaders had considerable knowledge of siegecraft is irrelevant to the question of siege machines being constructed by Alexios and supplied to the crusaders. A conclusion that these machines were not built and provided to the crusaders does not follow from the fact that the crusaders had considerable knowledge of siegecraft. During World War II, Great Britain had considerable knowledge of weaponry and military technology, yet that nation still required the supply of an enormous amount of arms and war munitions from the United States.

Rogers's arguments are equally dubious. He falsely states that the evidence regarding the engineers and craftsmen responsible for siege machinery at Nicaea is contradictory. There is no conflicting evidence regarding Byzantine assistance to the crusaders at Nicaea with respect to *helepoleis*. Greek sources substantiate the episode; Latin sources are silent on the matter. No Latin source provides evidence that contradicts the Greek sources for this incident. Rogers attempts to undermine the credibility of this episode by arguing that "there is no reference in Greek or Latin sources to a unit of Byzantine engineers serving with a crusading leader or with Tatikios' archers and infantrymen positioned near Raymond of St. Gilles's camp." He further objects that "no such devices appear in any of the Latin sources, some of which do mention the emperor's role in arranging the blockade of Lake Ascanius."¹⁸ The fact that the Greek sources do not provide additional information on this episode is no reason for discounting them, and the fact that Latin sources make no mention of it at all is no reason for rejecting the Greek accounts that do. As a final argument, Rogers wrongly claims that Anna's terminology for Alexios's siege machines is vague and that no such machines figure subsequently in her narrative.

Both France and Rogers fail to offer an assessment of the credibility of Anna's account of Byzantine siege machines at Nicaea based upon substantive evidence. Before attempting such an assessment, it is essential to dispel any notion that Anna's terminology for the siege machines is vague or that the machines described at Nicaea do not appear subsequently in her chronicle.

Anna states that her father undertook the construction of machines called *helepoleis*. This term has been interpreted by Rogers as "siege machines" and rendered as "machines" by France.¹⁹ The term *helepolis* was not a general name designating any siege-engine, however. It referred to the capital weapon of mechanized siegecraft in the Byzantine arsenal. It had originally been used to identify a giant mobile siege-tower. As a number of large mobile siege-towers were designed to carry battering-rams, the term *helepolis* came to designate the machine that later became known as the cat-castle, a mobile siege-tower fitted with a ram-mantlet. Later the term was applied to a ram-carrying mantlet.²⁰ As the capital weapon of siege warfare changed, with the introduction of new

¹⁸Ibid., 21.

¹⁹For *helepolis* as "siege machine," see *ibid.*, 21–22; as "machine," see France, *Victory in the East*, 162, 165; and as a generic term for any siege-engine, see D. Sullivan, "Tenth-Century Byzantine Offensive Siege Warfare: Instructional Prescriptions and Historical Practice," in *Byzantium at War (9th–12th c.)*, National Hellenic Research Foundation, Institute for Byzantine Research, International Symposium 4 (Athens, 1997), 191. The *ODB* (1:195) identifies the *ἐλεπόλεις* as a wooden tower (s.v. "Artillery and Siege Machinery").

²⁰For references to *helepolis* as a large mobile siege-tower, see E. W. Marsden, *Greek and Roman Artillery: Technical Treatises* (Oxford, 1971), 70–73, 84–90; Garlan, *Poliorkétique grecque*, 225–34; O. Lendle, *Text und*

or improved siege machines, the term *helepolis* was applied to the foremost siege-engine of the day, to keep pace with actual practice. From the sixth century onward, the term *helepolis* was used by a number of authors to designate heavy artillery: the trestle-framed trebuchet in its traction, hybrid, or counterweight forms.²¹

Anna's terms for artillery—"city-taker" (ἐλέπολις, *helepolis*), "rock-thrower" (πετροβόλος, *petrobolos*), and "stone-thrower" (λιθοβόλος, *lithobolos*)—all bear a Hellenistic pedigree. These terms, however, do not refer to the artillery of the Hellenistic era. By the sixth century, the heavy artillery of classical antiquity had been replaced by the trestle-framed traction trebuchet, and terms for ancient siege-engines, *helepolis* and *petrobolos*, were applied to the new machine (see above). Obviously the artillery denoted by these terms had changed fundamentally, while the terminology did not. Although the Byzantines did coin new terms for various types of trebuchets—*alakation* (αλακάτιον), *lambdarea* (λαμβδαρέα), *manganon* (μάγγανον), *manganikon* (μαγγανικόν), *petrarea* (πετραρέα), *tetrarea* (τετραρέα), and *cheiromangana* (χειρομάγγανα)—old-fashioned terms associated with mechanized warfare of the ancient world were widely used—*helepolis*, *lithobolos*, *petrobolos*, and *sphendonē* (σφενδόνη). By the fourteenth century, Latin loan words came into vogue: *praikoula* (πραίκουλα) and *tri[m]poutseto* (τρι[μ]πουτσέτο).

The terms *manganon* and *manganikon* were used by some authors specifically to denote the pole-framed trebuchet and by other authors to identify any model of trebuchet. The traction trebuchet with a *lambda*-shaped trestle frame was termed a *lambdarea* or *labdarea* (λαβδαρέα), while the trebuchet with a triangular-shaped trestle frame was named *helepolis*, *petrobolos*, *petrarea* (or *tetrarea*), and *sphendonē*. As the trestle-framed trebuchet evolved from traction to hybrid to counterweight forms, the names for it (*helepolis*, *petrobolos*, and *petrarea/tetrarea*) remained the same.

The pole-framed trebuchet was identified as an *alakation* and a *lithobolos*, while the pole-framed "hand-trebuchet," which was operated by a single man, was designated a *cheiromangana*. Following the Latin domination of the Byzantine Empire, the two most widely used counterweight trebuchets were identified by foreign loan words. The European *bricola*, a gravity-powered machine using a single pole for its frame (Fig. 5), was referred to as a *praikoula*, and the trestle-framed machine was called by its French name *trebuchet* (*tri[m]poutseto*).²²

Untersuchungen zum technischen Bereich der antiken Poliorketik (Wiesbaden, 1983), 36–70; as a cat-castle, see I Macc. 13:43–44; as a battering-ram, see Onasander, Στρατηγικός, in *Aeneas Tacticus, Asclepiodotus, Onasander, with an English Translation by Members of the Illinois Greek Club* (Cambridge, Mass., 1986), 508–9; Josephus, *The Jewish War*, trans. H. St. J. Thackeray (Cambridge, Mass., 1997), 2.553, 3.121, 3.226, 3.230, 5.275, 5.279, 5.281, 5.299, 5.317, 5.329, 5.473, 5.479, 6.236.26, 6.221, 6.393; *Ammiani Marcellini Rerum gestarum libri qui supersunt*, ed. W. Seyfarth (Leipzig, 1978), 23.4.10. In the 10th century, Leo the Deacon noted that the Romans used the term *helepolis* to refer to a battering-ram (*Leonis diaconi Caloensis historiae libri decem*, ed. C. B. Hase [Bonn, 1828], 2.7; 25.13).

²¹Theophylact Simocatta, *Historiae*, 2.16.11, 2.18.2, 3.11.2, 6.5.4, ed. de Boor and Wirth; Michael Attalates, *Historia*, ed. I. Bekker, CSHB (Bonn, 1853), 151; *Nicetae Choniatae Historia*, ed. J. L. van Dieten, CFHB, 11 (Berlin–New York, 1975), 18, 26, 38, 163, 168, 180, 282, 287, 298, 605, 606, 619, 624, 636 (hereafter Choniates, ed. van Dieten). For additional references to trebuchets in Byzantine sources from the 6th century onward, see G. T. Dennis, S.J., "Byzantine Heavy Artillery: The Helepolis," *GRBS* 39 (1998): 99–115.

²²For *tri[m]poutseto*, see *The Chronicle of Morea: A History in Political Verse, Relating the Establishment of Feudalism in Greece by the Franks in the Thirteenth Century*, ed. J. Schmitt (Groningen, 1967), 852, 1412, 1481, 1700, 8430, 9155. For *praikoula*, or *prekoula*, see *Nicetae Choniatae Historia*, ed. I. Bekker, CSHB (Bonn, 1835), 174.27; 175.29. I would like to thank George T. Dennis, S.J., for the references to *praikoula*.

Greek authors clearly had a number of terms to choose from to denote the trebuchet. Some, like Anna, were partial to the old-fashioned terminology, while others used new terms or settled for a nomenclature combining old names with new.²³ It is not unusual that Anna would use Hellenistic terms for the artillery of the Komnenian period, since instances abound in her text of old words being used to refer to new things.²⁴ Descriptive details provided in the *Alexiad* indicate that Anna used the term *helepolis* to denote heavy artillery, and not a mobile siege-tower. This machine is employed like the *petrobolos* to batter walls, and it is used aboard ships in order to assist in the siege of a maritime city (Durazzo on the Adriatic Sea).²⁵ Since *helepolis* designates the capital weapon of its time,

²³On Byzantine terms for artillery, see Huuri, "Geschützwesens," 79–93, 148, 212–16; Chevedden, "Artillery of King James I," 64–67; idem, "Hybrid Trebuchet," 199–200; Sullivan, "Byzantine Siege Warfare," 189–90; Dennis, "Byzantine Heavy Artillery."

²⁴G. Buckler, *Anna Comnena: A Study* (Oxford, 1929), 488–97.

²⁵At the siege of Kastoria, Alexios I Komnenos used *helepoleis* and *petroboloi* to breach the walls of the city (AK 6.1.2; AK [Dawes] 138; AK [Sewter] 181). At the siege of Dristra, Alexios made a breach in the walls with *helepoleis* (AK 7.3.2; AK [Dawes] 173; AK [Sewter] 222). At the siege of Chios, Constantine Dalassenos battered the walls "with a host of *helepoleis* and *petroboloi*, and the ramparts between the two towers were destroyed" (AK 7.8.3; AK [Dawes] 183; AK [Sewter] 234). At the siege of Durazzo in 1081, Robert Guiscard's "plan was to surround [the city] the moment he got there with *helepoleis* by land and sea—for two reasons: first, he would terrify the inhabitants; secondly, having isolated them completely, he would take the city at the first assault" (AK 3.12.2; AK [Sewter] 131). Dawes's translation of this passage distorts the literal meaning of the Greek text and implies that *helepoleis* were only sited on land, not aboard ships: "His plan was to surround [the city], when he reached it, with [*helepoleis*] both on the land- and sea-side so as to strike dismay into the hearts of the inhabitants and also by thus hemming them in completely, to take the town by assault" (AK [Dawes] 95). Trebuchets were commonly mounted on ships in order to assist in the siege of a coastal city. According to Marsden, ship-mounted artillery could assist in such a siege in three ways: "First, it helped the besieger to block the harbour and thus cut the city off completely from outside contacts. Secondly, the besieger could compel the defenders to expend considerable energy in protecting the maritime area of their city and thus prevent them concentrating their entire defensive efforts against his assaults by land. Finally, if conditions were favourable, the besieger might actually direct his principal attack, properly supported by artillery, against a selected point on the seaward side, having taken fuller advantage of the privilege, naturally enjoyed by all besiegers, of choosing which section of the circuit to attack" (Marsden, *Greek and Roman Artillery: Historical Development*, 169–70). Arabic sources record the use of ship-mounted trebuchets at the sieges of Baghdad in 987/813 and 251/865, and during the Zanj revolt in 269/883 (Abū Ja'far Muḥammad ibn Jarīr al-Ṭabarī, *Ta'rikh al-rusul wa-al-mulūk* [Annales], ed. M. J. de Goeje et al., ser. 3, 15 vols. [Leiden, 1879–1901], 3:936, 1626, 2025 [the references are to series and page number, not to volume and page number]). Arabic sources note that the Almohads used sea-borne trebuchets against Christian forces defending Mahdia in 553/1158 ('Alī ibn 'Abd al-Lāh ibn Abī Zar', *al-Anīs al-muṭrib bi-rawḍ al-qirṭās*, ed. C. J. Tornberg [Uppsala, 1843], 129); and crusaders used a ship-mounted trebuchet against Muslims defending Acre in 1189–92 and against Muslims attacking Acre in 1291 (Ibn al-Muqaffa', *History of the Patriarchs*, 3.2:89 [Arabic text], 151 [trans.]; al-Malik al-Mu'ayyad Abū al-Fidā', *al-Mukhtaṣar fī akhbār al-bashar* [Cairo, 1907–8], 4:25). In 1142, Emperor John II Komnenos lashed fishing boats and light transports together to form a platform on which *helepoleis* were placed in order to bombard the fortifications along Lake Pousgousē (Beyşehir Gölü) (Choniates, *Historia*, ed. van Dieten, 38; *O City of Byzantium, Annals of Niketas Choniates*, trans. H. J. Magoulias [Detroit, 1984], 22). During the "Fourth" Crusade, the crusaders used sea-borne trebuchets to assault Constantinople in 1203 and 1204 (Geoffrey de Villehardouin, *Chronicles of the Crusades*, trans. M. R. B. Shaw [Harmondsworth, 1963], 68, 70, 89; Robert of Clari, *The Conquest of Constantinople*, trans. E. H. McNeal [New York, 1936], 70, 71, 73). In 1241 the Genoese launched an amphibious attack on Savona using ship-mounted trebuchets (*Annali genovesi di Caffaro e de' suoi continuatori*, ed. L. T. Belgrano and C. Imperiale di Sant'Angelo, 4 vols. [Rome, 1890–1929], 3:120). In 1249 the crusaders launched an assault on Damietta using trebuchets mounted on ships (M. Paris, *Additamenta* (London, 1639), 157; F. W. Brooks, "Naval Armaments in the Thirteenth Century," *Mariner's Mirror* 14 [1928]: 120–21; J. Hewitt, *Ancient Armour and Weapons in Europe*, 3 vols. [Oxford, 1855–60], 1:352). The Hundred Years' War also witnessed the use of trebuchets mounted on vessels

Anna almost certainly uses the term to refer to the most powerful piece of artillery in the Byzantine siege arsenal: the trestle-framed hybrid trebuchet.²⁶

Hellenistic usage distinguished artillery by size. A large catapult was designated a “rock-thrower” (*petrobolos*) and a small catapult a “stone-thrower” (*lithobolos*).²⁷ Accordingly, Anna employs these two terms to identify the two basic types of traction-powered artillery of her day. She designates the larger trestle-framed trebuchet as a *petrobolos*²⁸ and the smaller pole-framed trebuchet as a *lithobolos*.²⁹ On one occasion, *petrobolos* is used interchangeably with *helepolis*. This is apparently due to the fact that both machines have a trestle frame.³⁰ The linkage of *lithobolos* with the pole-framed machine seems certain because Anna records the placement of this artillery piece on walls and on mobile siege-towers, the very locations where this light artillery weapon was generally sited.³¹

Following the siege of Nicaea, Anna records that the Byzantines made subsequent use of *helepoleis* at the sieges of Laodicea in 1104 and Mylos.³² Anna cites the use of *helepoleis* prior to Nicaea at the sieges of Aretai,³³ Durazzo,³⁴ Kastoria,³⁵ Apollonias,³⁶ Dris-tra,³⁷ Chios,³⁸ and Abydos.³⁹ The conclusion that Anna’s terminology is vague or that she makes no further mention of *helepoleis* after the siege of Nicaea is not supported by the evidence. When referring to artillery, Anna uses the term *helepolis* more than any other word.

The main objection to Anna’s account of Alexios’s *helepoleis* seems to be that it comes from a biased source and, therefore, cannot be regarded as credible. According to Rog-

(J. Sumpton, *The Hundred Years War: Trial by Battle* [Philadelphia, 1991], 207). The Castilian fleet under Pedro the Cruel attacked Barcelona on 11 June 1359 with trebuchets mounted on the poops of their galleys (Peter IV of Aragon [III in Catalonia], *Crònica de Pere e Cerimoniós*, in *Les quatre grans cròniques*, Jaume I, Bernat Desclot, Ramon Muntaner, Pere III, ed. F. Soldevila [Barcelona, 1971], 6.24); and the Genoese assaulted Kyrenia on the island of Cyprus on 10 February 1374 with sea-borne trebuchets (Leontios Makhairas, *Recital Concerning the Sweet Land of Cyprus Entitled “Chronicle,”* ed. R. M. Dawkins, 2 vols. [Oxford, 1932], 1:463–65). Marino Sanudo describes the construction of a long-range trebuchet for use on a ship, and Mariano Taccola describes and illustrates a coastal fortress being assaulted by a sea-borne trebuchet (Marino Sanudo, called Torsello, *Liber secretorum fidelium crucis super Terrae Sanctae recuperatione et conservatione* [Hanover, 1611], 80; Mariano Taccola, *De machinis: The Engineering Treatise of 1449*, 2 vols. [Wiesbaden, 1971], 1:119; 2:200).

²⁶AK 2.8.5, 3.12.2, 4.1.2, 4.4.4, 4.5.1, 6.1.1, 6.1.2, 6.13.1, 7.3.2, 7.8.3, 7.8.10, 9.3.3, 10.9.3, 11.1.3, 11.1.6, 11.2.1, 11.11.7, 13.3.11, 13.5.4, 13.5.6, 14.1.6; AK (Dawes) 62, 95, 98, 105, 138, 163, 173, 183, 187, 219, 258, 270, 271, 297, 330–31, 336, 361; AK (Sewter) 94, 131, 135, 141, 143, 181, 210, 222, 234, 237, 275, 319, 334, 336, 366, 404, 409, 410, 438.

²⁷Lawrence, *Greek Aims in Fortifications*, 72.

²⁸AK 2.8.5, 6.1.2, 7.8.3, 9.3.3, 11.2.5, 13.2.2, 14.1.6, 14.2.11; AK (Dawes) 62, 138, 183, 219, 272, 326, 361, 366; AK (Sewter) 94, 181, 234, 275, 337, 399, 438, 443.

²⁹AK 4.1.1, 4.1.2, 4.4.6; AK (Dawes) 98, 104; AK (Sewter) 135, 142.

³⁰The term *petrobolos* is used interchangeably with *helepolis* in Anna’s account of the siege of Nicaea (AK 11.1.3, 11.2.1, 11.2.5; AK [Dawes] 270–72; AK [Sewter] 334, 336, 337).

³¹AK 4.1.1, 4.1.2, 4.4.6; AK (Dawes) 98, 104; AK (Sewter) 135, 142.

³²AK 11.11.7, 13.5.4, 13.5.6; AK (Dawes) 297, 336; AK (Sewter) 366, 409–10.

³³AK 2.8.5; AK (Dawes) 62; AK (Sewter) 94.

³⁴AK 3.12.2, 4.1.2, 4.4.4, 4.5.1; AK (Dawes) 95, 98, 105; AK (Sewter) 131, 135, 141, 143.

³⁵AK 6.1.1, 6.1.2; AK (Dawes) 138; AK (Sewter) 181.

³⁶AK 6.13.1; AK (Dawes) 163; AK (Sewter) 210.

³⁷AK 7.3.2; AK (Dawes) 173; AK (Sewter) 222.

³⁸AK 7.8.3, 7.8.10; AK (Dawes) 183, 187; AK (Sewter) 234, 237.

³⁹AK 9.3.3; AK (Dawes) 219; AK (Sewter) 275.

ers, “her story of imperial siege machinery at Nicaea appears primarily intended to extol her father’s military knowledge and concern for the crusaders.”⁴⁰ France also believes that Anna sought “to praise her father at the expense of the hated western barbarians.” Again France provides a fallacious argument to prove his point. Anna, he tells us, “would have us believe that the Latins were quite unable to face a city of the strength of Nicaea and only captured it because he sent them siege engines of his own devising.”⁴¹ Anna’s account of the siege of Nicaea is altogether different from France’s characterization of it. The city capitulated; it was not taken by assault. It is true that Anna does exhibit biases and displays a tendency to eulogize her father, but do such inclinations play a part in her account of the siege of Nicaea? And if so, do they render her version of the siege untrustworthy, particularly with respect to Alexios’s *helepoleis*?

Anna’s allegedly biased narrative is belied by her praise of crusader engineering expertise at Nicaea (see below). John Birkenmeier has observed that Anna’s tendency to extol her father appears to be “in direct proportion to Anna’s lack of detailed information” of the events she describes.⁴² For the siege of Nicaea, Anna could rely on ample data to construct her narrative. She doubtless made use of eyewitness accounts and may even have used contemporary written sources.⁴³ We are certain that the episode pertaining to Alexios’s *helepoleis* comes from a contemporary account, because it appears in the preface of the *Panoplia* written ca. 1100 by the learned monk Euthymios Zygabenos, who was closely associated with Alexios.⁴⁴ Zygabenos adds that the siege-engines invented by Alexios (μηχανημάτων ἐπίνοιαι, *mēkhanēmatōn epinoiai*) were not inferior to the machines designed by Archimedes and Palamedes. The testimony of Zygabenos is significant and supports Anna’s account of her father’s artillery innovations at Nicaea. The question now turns on whether the assertion of Zygabenos is credible or not. A number of factors support the reliability of his claim.

The crusaders were woefully lacking in artillery and siege equipment when they arrived on the shores of the Bosporos. At Constantinople, Anna relates that the crusaders failed in an assault on the city walls because they possessed no *helepoleis*.⁴⁵ Apparently the crusaders proceeded on their expedition with little or no ordnance and relied on opportunistic methods for assembling batteries of machines when the situation required it. When the need for artillery arose, the crusaders depended on the initiative of their

⁴⁰Rogers, *Latin Siege Warfare*, 22.

⁴¹J. France, “Technology and the Success of the First Crusade,” in *War and Society in the Eastern Mediterranean, 7th–15th Centuries*, ed. Y. Lev (Leiden, 1997), 171.

⁴²J. W. Birkenmeier, “The Development of the Comnenian Army” (Ph.D. diss., Catholic University of America, 1998), 5. On the credibility of Anna as a historian, see Buckler, *Anna Comnena*, 225–478; J. Chrysostomides, “A Byzantine Historian: Anna Comnena,” in *Medieval Historical Writing in the Christian and Islamic Worlds*, ed. D. O. Morgan (London, 1982), 30–46; G. A. Loud, “Anna Komnena and Her Sources for the Normans of Southern Italy,” in *Church and Chronicle in the Middle Ages. Essays Presented to John Taylor*, ed. I. Wood and G. A. Loud (London, 1991), 41–57.

⁴³AK 14.7.3–7; AK (Dawes) 380–82; AK (Sewter) 459–61. In a recent analysis of Anna’s sources, James Howard-Johnston has proposed that much of the *Alexiad* was the work of Anna’s husband, Nikephoros Bryennios: J. Howard-Johnston, “Anna Komnene and the *Alexiad*,” in *Alexios I Komnenos: Papers of the Second Belfast Byzantine International Colloquium, 14–16 April 1998*, ed. M. Mullett and D. Smythe, *Belfast Byzantine Texts and Translations* 4.1 (Belfast, 1996), 260–302.

⁴⁴Euthymios Zygabenos, *Panoplia*, PG 130:20; Buckler, *Anna Comnena*, 414 n. 3. On Zygabenos, see AK 15.9.1; AK (Dawes) 415; AK (Sewter) 500.

⁴⁵AK 11.1.7; AK (Dawes) 271; AK (Sewter) 335.

commanders and sought the assistance of the Byzantines for an adequate supply of ordnance for their siege operations. The crusader commanders could rely upon their own expert technicians or could hire native engineers to construct artillery. Anna, for example, credits Raymond of St. Gilles with setting up *helepoleis* for an assault on the walls of Nicaea. She also praises the cat-castle that he built as being constructed “very scientifically.”⁴⁶ There is no question that the crusaders could draw upon specialist technicians to construct and operate siege-engines. This does not preclude Byzantine assistance in the provision of artillery at Nicaea.

The critical problem for the crusaders was assembling a sufficient number of artillery pieces and siege-engines in order to overcome a number of well-fortified cities that lay in their path. The city of Nicaea was second only to Constantinople in terms of the strength of its defenses.⁴⁷ Anna relates that Alexios “had thoroughly investigated Nicaea and . . . judged that it could not possibly be captured by the Latins, however overwhelming their numbers. . . . The great strength of its walls, he was sure, made Nicaea impregnable; the Latins would never take it.”⁴⁸ So the emperor had *helepoleis* constructed and sent to the crusaders. The crusaders did not need additional manpower; they needed machines. Even so, Alexios did provide the crusaders with additional manpower—2,000 Byzantine shock troops (*πελτασταις*, *peltasts*). If the emperor responded to needs that were nonessential—additional manpower—would he not have addressed vital needs as well? Both France and Rogers argue otherwise and dismiss substantive evidence that conflicts with their position.⁴⁹

Fairly objective Latin authors, such as Fulcher of Chartres, acknowledge that Alexios’s aid and counsel was essential to the crusader expedition.⁵⁰ Thus, there is no reason to doubt that his assistance extended to the supply of artillery, even though Latin sources are silent on the matter. By the time the Latin sources for the First Crusade were written, relations between Byzantium and the West had soured, and this fact may explain why Latin accounts are not forthcoming regarding the full nature of Byzantine support at

⁴⁶AK 11.1.3, 11.1.6; AK (Dawes) 270–71; AK (Sewter) 334–335. The cat-castle built by Raymond of St. Gilles was a combination of a “cat” or mantlet and a “castle” or mobile siege-tower. Inside the “cat,” expert sappers loosened “the tower at its foundations with iron instruments,” while above on the “castle” other soldiers battered the wall and fought with defenders. Because Greek, like Arabic, had no word for this composite device, Anna calls it both a “tower” and a “tortoise.” This instrument of war was not unknown in antiquity. In 211 B.C., Philip V of Macedon besieged Echinus with a cat-castle (Polybius, *Histories* 9.41). The evidence for mobile siege-towers at the siege of Nicaea found in Anna’s text and in the *Gesta Francorum* is discounted by Rogers who contends that “the short period of construction involved and the description of the attack make it very doubtful that wall-dominating siege-towers were employed” (Rogers, *Latin Siege Warfare*, 22). France also insists that the assaults on Nicaea did not involve the use of siege-towers (France, “Technology,” 172).

⁴⁷On the fortifications of Nicaea, see A. M. Scheider and W. Karnapp, *Die Stadtmauer von Iznik-Nicaea* (Berlin, 1938); Foss and Winfield, *Byzantine Fortifications*, 79–117, 261–81; S. Eyice, *Iznik-Nicaea: The History of the Monuments* (Istanbul, 1991).

⁴⁸AK 11.2.1, 11.2.3; AK (Dawes) 271–72; AK (Sewter) 335–36.

⁴⁹AK 11.2.4; AK (Dawes) 272; AK (Sewter) 336; France, *Victory in the East*, 122, 144; Rogers, *Latin Siege Warfare*, 19.

⁵⁰Fulcher of Chartres, *Historia Hierosolymitana (1095–1127)*, ed. H. Hagenmeyer (Heidelberg, 1913), 178–79; idem, *A History of the Expedition to Jerusalem, 1095–1127*, trans. F. R. Ryan (New York, 1973), 80. France also admits that the crusaders may have relied on Byzantine poliorcetic expertise: “The crusaders did not lack knowledge of siege-equipment, but in the early stages they lacked technical grasp and may have owed something to Byzantine engineers” (France, “Technology,” 173).

Nicaea. It is also important to take into consideration the schematic nature of all of the accounts of the siege of Nicaea. None of our sources, Greek or Latin, provides full details of the siege. Information lacking confirmation from other sources, particularly non-Latin ones, should not be discounted out of hand.⁵¹

Zygabenos's account of Alexios's siege machines, even allowing for adulation and exaggeration, is important and credible. He does not adhere to the usual *topoi* in his praise of Alexios, such as his bravery, justice, or philanthropy, but instead emphasizes the emperor's mechanical genius. The comparison of Alexios's machines with the inventions of Archimedes and Palamedes indicates that the devices introduced by the emperor at Nicaea were a major innovation, not a minor step in an evolutionary chain of artillery development. While the term *mēkhanēmātōn* that Zygabenos employs to refer to Alexios's siege-engines may designate artillery as well as other siege machines, Anna clearly links her father's innovative efforts at Nicaea to heavy artillery (*helepoleis*).

The Byzantine military tradition emphasized innovation and the development of new technologies applicable to warfare. Byzantine military treatises cite a number of new implements of war introduced by Byzantium: Greek fire; a portable, hand-held device for shooting this deadly substance known as a *cheirosiphon* (χειροσίφων); a new type of *testudo* called a *laisa* (λαίσσα), and protection devices for expeditionary camps.⁵² In the field of artillery, the Byzantines reached a highly advanced stage of development. The great age of Byzantine conquest under Leo VI (886–912), Constantine VII (945–959), Nikephoros II Phokas (963–969), John I Tzimiskes (969–976), and Basil II (976–1025) placed a premium on the development of artillery, and historical sources record remarkable achievements attained by Byzantine artillery specialists. During the reconquest of Crete in 960–961, a Byzantine trebuchet is said to have hurled a live ass over the walls of Chandax (Heraklion) to the starving Muslim inhabitants inside. Kalervo Huuri has estimated that the ass must have weighed between 120 and 200 kilograms (an adult Asian ass can weigh up to 290 kg).⁵³ The two most powerful trebuchets of the eleventh century were Byzantine machines. The first, built by Emperor Basil II, launched stone-shot weighing between 111 and 200 kilograms; and the second, used by Emperor Romanos IV Diogenes in 1071, discharged missiles weighing 96 kilograms.⁵⁴ Clearly, the Byzantine Empire was

⁵¹For recent assessments of Anna Komnene's account of the "First" Crusade, see R.-J. Lilie, "Der Erste Kreuzzug in der Darstellung Anna Komnenes," in *VARIA II*, Poikila Byzantina 6 (Bonn, 1987), 49–148; idem, "Anna Komnene und die Lateiner," *BSI* 54 (1993): 176–79; idem, *Byzantium and the Crusader States, 1096–1204*, trans. J. C. Morris and J. E. Ridings (Oxford, 1993), 4, 26, 34–37, 46, 51–53; J. Shepard, "When Greek Meets Greek: Alexius Comnenus and Bohemond in 1097–98," *BMGS* 12 (1988): 185–277; idem, "Cross-Purposes: Alexius Comnenus and the First Crusade," in *The First Crusade: Origins and Impact*, ed. J. Phillips (Manchester, 1997), 107–29; idem, "'Father' or 'Scorpion'? Style and Substance in Alexios's Diplomacy," in Mullett and Smythe, *Alexios I Komnenos* (as above, note 43), 1:68–132; R. D. Thomas, "Anna Komnena's Account of the First Crusade: History and Politics in the Reigns of the Emperors Alexios I and Manuel I Komnenus," *BMGS* 15 (1991): 269–312.

⁵²On Byzantine military innovations, see E. McGeer, *Sowing the Dragon's Teeth: Byzantine Warfare in the Tenth Century* (Washington, D.C., 1995); Sullivan, "Byzantine Siege Warfare," 179–200; G. T. Dennis, S.J., "Were the Byzantines Creative or Merely Imitative?" *ByzF* 24 (1997): 1–9.

⁵³Theodosios Diaconos, *Theodosii Diaconi de Creta capta*, ed. H. Criscuolo (Leipzig, 1979), 28, v. 718 ff; Huuri, "Geschützwesen," 91.

⁵⁴Basil II's hybrid trebuchet (*baban*) was installed in the citadel of Bitlis. In 1054 the Seljuq sultan Toghriq Beg Muhammad transported it to Manzikert where he used it to bombard the city with stone-shot weighing between 111 and 200 kilograms (Matthew of Edessa, *Patmut'yun* [Jerusalem, 1869], 142–45; A. E. Dostourian,

second to none in the development of artillery. Alexios built upon a legacy of advanced military technology devoted to artillery when he constructed at Nicaea *helepoleis* of several types, “and most of them were not fashioned according to conventional designs for such machines.”

The conclusion reached by Rogers that “there is no clear evidence indicating that the Byzantines provided the crusaders with siege technology or specific machines”⁵⁵ rests upon a fallacious method of proof. To disprove that the Byzantines provided the crusaders with siege machines, one must do more than demonstrate that Byzantine non-assistance was possible. One must show that Byzantine non-assistance was more probable than their assistance. Both Rogers and France fail to make a credible case for Byzantine non-assistance with respect to artillery and other siege-engines. Their arguments rest on assertion, not evidence. Considering the affirmative evidence for Byzantine assistance, and taking into account that there is no evidence for their non-assistance, it appears exceedingly likely that the Byzantines furnished the crusaders besieging Nicaea with siege-engines, particularly heavy artillery.

What kind of heavy artillery was provided? The hybrid trebuchet was the capital artillery weapon of this period. However, at the time Nicaea was besieged, it was under-

Armenia and the Crusades, Tenth to Twelfth Centuries: The Chronicle of Matthew of Edessa [Lanham, 1993], 87–88; Aristakēs Lastiverts’i, *Patmut’iwn Aristakisi Lastivertc’woy*, ed. K. N. Juzbashan [Erevan, 1963], 92–93; idem, *Aristakes Lastivertc’i’s History*, trans. R. Bedrosian [New York, 1985], 103–5; Chevedden, “Hybrid Trebuchet,” 187–88; Chevedden et al., “Traction Trebuchet,” table 1). Arabic sources describe the large trebuchet of Romanos IV Diogenes in the siege train of the emperor just prior to the battle of Manzikert in 1071 (Fath ibn ‘Alī al-Bundārī, *Zubdat al-nuṣrah wa-nukhbat al-‘uṣrah*, ed. M. T. Houtsma, *Recueil de textes relatifs à l’histoire des Seljoucides 2* [Leiden, 1889], 42; Sibṭ Ibn al-Jawzī, *Mir’āt al-zamān fī ta’rīkh al-a’yān: al-ḥawādith al-khāṣṣah bi-ta’rīkh al-Salājiqah bayna al-sanawāt, 1056–1086* [Ankara, 1968], 148; Chevedden, “Hybrid Trebuchet,” 188; Chevedden et al., “Traction Trebuchet,” table 1).

⁵⁵ Rogers, *Latin Siege Warfare*, 25. A tendency to discount or ignore Greek sources has impeded our understanding of the siege of Nicaea. Rogers examines “the almost supernatural appearance” of a Lombard engineer who designed a mantlet in the final stages of the siege that was successful “because the sides of its roof were better sloped.” According to Albert of Aachen and William of Tyre, it was this device that brought about the surrender of the city (Rogers, *Latin Siege Warfare*, 19–20, 23–24). At the time of the siege of Nicaea, the Byzantines were renowned for their construction of mantlets. The mysterious Lombard appears to have been thoroughly conversant with Byzantine methods of siegecraft and construction of siege machines. During the 12th century, a particular type of mantlet used by the crusaders was identified by a Latin compound derived from Middle Greek *laisa*, indicating that the crusaders were indebted to Byzantine expertise in the construction of certain siege machines. The Latin term was *cercleia*. The first part of the word (*cerc-*) means “hooped” (from *circus*), and the second part (*-leia*) is the Latin cognate of *laisa*, a Greek term for a mantlet “made by plaiting vine twigs of fresh cut willow branches in the form of arches” (Heron of Byzantium, *Poliorketika*, ed. C. Wescher, *Poliorcétique des Grecs* [Paris, 1867], 207, quoted in Sullivan, “Byzantine Siege Warfare,” 196). The Greek term was itself borrowed from Slavic during the 9th century and appears in a number of Byzantine sources from the 10th through the 11th century. Neither Rogers nor France identifies this mantlet in the Latin sources. On Byzantine sapping operations with mantlets, see G. T. Dennis, S.J., *Three Byzantine Military Treatises* (Washington, D.C., 1985), 34–43, 316–19; E. McGeer, “Tradition and Reality in the *Taktika* of Nikephoros Ouranos,” *DOP* 45 (1991): 129–40; idem, “Byzantine Siege Warfare in Theory and Practice,” in Corfīs and Wolfe, *The Medieval City under Siege* (as above, note 6), 123–29; idem, *Sowing the Dragon’s Teeth*, 159, 161, 163, 167; Sullivan, “Byzantine Siege Warfare,” 196–97, 200. On the Latin term *cercleia*, see Ricardus, *Itinerarium peregrinorum et gesta Regis Ricardi*, ed. W. Stubbs, 2 vols., *Rolls Series, Rerum Britannicarum Medii Aevi Scriptores* 38 (London, 1864), 1:220, 224; H. J. Nicholson, *Chronicle of the Third Crusade: A Translation of the Itinerarium peregrinorum et gesta Regis Ricardi* (Aldershot, 1997), 210, 213; Ambroise, *L’Estoire de la Guerre Sainte*, ed. G. Paris, *Collection de Documents Inédits sur l’Histoire de la France* (Paris, 1897), vv. 3203, 4688, 4817, 4827, 4833, 4931, 4936.

going a change. Anna relates that most of Alexios's pieces of heavy artillery (*helepoleis*) were not constructed according to the usual designs. This suggests that Alexios was following a new design. Considering that the next creative approach in artillery was to result in the invention of the counterweight trebuchet, it is highly probable that the new pieces of artillery at Nicaea, "which amazed everyone," were gravity-powered machines.

The trebuchet is a complex device, an amalgamation of interdependent component parts that, when working in proper relation, produce a successful machine. The invention of the counterweight trebuchet was most probably the product of a sustained interaction of engineering techniques, creative abilities, and experimentation. The refinements incorporated in the design of the hybrid trebuchet that finally resulted in a workable counterweighted machine lie obscured from the historian's gaze, but the process of invention doubtless involved a conceptual leap in the fundamental operation of the trebuchet, new design choices, and a trial-and-error method. One of the critical innovations that singled the transition from a traction-powered machine to a gravity-powered one was the lengthening of the sling. With the elimination of the pulling crew, space was created directly under the beam for the placement of a trough, or runway, for the sling. The trough made it possible to increase the length of the sling, and a longer sling made it possible to greatly increase the range of the machine. To enhance the power of his artillery at Nicaea, Alexios may have replaced human power with gravity power and lengthened the sling. Whatever steps he did take in the development of the trebuchet at Nicaea, they were significant enough to be ranked with the works of Archimedes, the most famous inventor of ancient Greece. The association of Alexios with Archimedes indicates that an important breakthrough in the design and construction of the trebuchet occurred at the siege of Nicaea. Given the imminent appearance of gravity-powered artillery, this breakthrough is most likely to have been the development of the first counterweight trebuchet.

EVIDENCE FOR THE EXISTENCE OF THE COUNTERWEIGHT TREBUCHET

Niketas Choniates

Following the siege of Nicaea, evidence for the appearance of the counterweight trebuchet begins to mount. The earliest historical narrative to provide descriptive details of the counterweight trebuchet is a twelfth-century Byzantine account of Niketas Choniates. In describing the siege of Zevgminon in 1165, Niketas states that, "Andronikos [Komnenos] took charge of a 'rock-throwing engine' [*petrobolous mēkhanas*] and by using the sling [*sphendonē*], the windlass [*στροφάλος, strophalos*], and the beam [*λύγος, lugos*], shook the section of the wall between the two towers violently."⁵⁶

This machine is unquestionably a counterweight trebuchet because it is equipped with a winch or windlass (*strophalos*), which neither the traction nor hybrid trebuchets require to draw down the beam in order to prepare it for launch. The word *lugos*, here

⁵⁶Choniates, ed. van Dieten, 134. Harry J. Magoulias has translated this passage as "Andronikos took charge of a stone-throwing engine and by using the sling, winch, and screwpress, shook the section of the wall between the two towers violently" (*O City of Byzantium*, 76).

translated as “beam,” can be interpreted as a withe, or branch,⁵⁷ or several branches bound together, and so may refer to the rotating beam of the trebuchet, which can either be composed of a single shaft of wood or of several bound together. The large hybrid trebuchet of Romanos IV Diogenes had a large composite beam composed of eight spars.⁵⁸ The verb from which *lugos* is derived has a secondary meaning of “to throw,” or “to turn,” or “play, as a joint in the socket.”⁵⁹ These actions correspond perfectly with the operation of a rotating beam of a trebuchet, and hence the identification of *lugos* with this component of the trebuchet appears to be certain. During the siege of Prosakos in 1197, Choniates writes that the man responsible for discharging the stone missile from the “rock-throwing engine” (πετρόβολα μηχανήματα, *petrobola mēkhanēmata*) turned the *lugos* around and aimed the sling, which also suggests that the *lugos* is the rotating beam of the trebuchet.⁶⁰ Earlier, at the siege of Nicaea in 1184, Choniates states that Andronikos “positioned the *helepoleis*, carefully examining the sling [*sphendonē*], [and] secured both the beam [*lugos*] and the windlass [*strophalos*].”⁶¹

The *De cerimoniis*, which provides details of the provisioning of the failed Byzantine expedition against Crete under Constantine Gongyles in 949, indicates that block-and-tackle equipment (τροχίλια, *trochilia*) was required for the various trebuchets (*manganika*) used for the expedition.⁶² It is uncertain whether the block-and-tackle equipment was used for the assembly of the machines or for the hauling down of the throwing arm to prepare the artillery for launch. Even if the block-and-tackle equipment was used as a pull-back mechanism for the throwing arm, such as we find on Ṭarsūsī’s counterweight trebuchet (see below, Fig. 1 and App. 2), there is no evidence for a windlass being used in the tenth century for the hauling down of the beam of a trebuchet. The use of such a powerful hauling apparatus for the launching of projectiles from a trebuchet in the twelfth century is a strong indicator of the existence of the counterweight trebuchet. The fact that the beam and the windlass of the *helepolis* used at Nicaea in 1184 must be secured also indicates that this trebuchet is a counterweight, not a traction or hybrid, machine.

Ṭarsūsī’s Double-Purpose Machine

The earliest full-length description and illustration of a counterweight trebuchet is found in Ṭarsūsī’s military manual, *Tabṣīrah fī al-ḥurūb*, written around 583/1187 (Fig. 1 and App. 2).⁶³ The portion of the treatise that deals with the counterweight trebuchet has

⁵⁷LSJ, 1063.

⁵⁸Chevedden, “Hybrid Trebuchet,” 188.

⁵⁹LSJ, 1063.

⁶⁰Choniates, *Historia*, ed. van Dieten, 506.

⁶¹Ibid., 282; *O City of Byzantium*, 156.

⁶²*De cerimoniis aulae byzantinae*, ed. J. J. Reiske, CSHB, 2 vols. (Bonn, 1829–30), 1:670. Sullivan believes that the word *trochilia* is suggestive of a windlass and asserts that the presence of a windlass supports his contention that torsion-powered artillery was used by the Byzantines (Sullivan, “Byzantine Siege Warfare,” 199).

⁶³The full title of Ṭarsūsī’s military manual is *Tabṣīrat arbāb al-albāb fī kayfīyat al-najāh fī al-ḥurūb min al-aswā’ wa-nashr al-lām al-i-lām fī al-‘udād wa-al-ālāt al-mu‘īnah ‘alā liqā’ al-a’dā’* (Instruction of the masters on the means of deliverance in wars from disasters, and the unfurling of the banners of information: Equipment and engines which aid in encounters with enemies) (hereafter *Tabṣīrah fī al-ḥurūb*). The autograph manuscript of this text in the Bodleian Library at Oxford University (MS Hunt. 264), hereafter cited as B, has been partially

unfortunately been incorrectly edited and translated by Claude Cahen.⁶⁴ All subsequent scholars have drawn upon Cahen's flawed text for an understanding of Ṭarsūsī's counterweight machine. His defective text was widely disseminated by Bernard Lewis, who translated it into English and published it in an anthology of original source materials

edited by Claude Cahen ("Un traité d'armurerie composé pour Saladin," *Bulletin d'études orientales* 12 [1947–48]: 103–63) and A. Boudot-Lamotte (*Contribution à l'étude de l'archerie musulmane* [Damascus, 1968]). A later manuscript of this text, copied by Muḥammad ibn Salmān in 790/1388, is in the Süleymaniye Library in Istanbul (Ayasofya Collection MS 2848 mü), hereafter cited as A. An Arabic edition of the entire text, utilizing the above manuscripts, has recently been published by Karen Šādir (Murḍī b. 'Alī b. Murḍī al-Ṭarsūsī, *Mawsū'at al-asliḥah al-qadimah: al-mawsūm Tabṣīrat arbāb al-albāb fī kayfīyat al-najāh fī al-ḥurūb min al-anwā'* [sic] *wa-nashr a'lām al-i'lām fī al-'udād wa-al-ālāt al-mu'ayyanah* [sic] 'alā liqā' al-a'dā', ed. Karen Šādir [Beirut, 1998]). The earliest extant illustration of a counterweight trebuchet appears in *Tabṣīrah fī al-ḥurūb* (Oxford, Bodl. MS Hunt. 264, fols. 134v–135r) and is reproduced in Cahen, "Traité," pl. 3, fig. 14, and in Chevedden, "Artillery of King James I," pl. 7.

⁶⁴The section pertaining to the counterweight trebuchet in the Bodleian manuscript of this text, which Cahen edited, contains two facing pages (fols. 134v and 135r); the upper portion is filled with lines of text and the lower portion is embellished with an illustration of a counterweight trebuchet (Fig. 1). Because the illustration stretches across both of the pages, the text does not follow the usual reading order, as Cahen supposed, with the successive lines of folio 134v being followed by the successive lines of folio 135r. Instead, the lines are arranged to be read straight across both pages, so that the continuation of the first line of folio 134v is the first line of folio 135r, and so forth. Cahen's error was compounded by the fact that he inserted three nonexistent lacunas in the text on fol. 134v. This impeded possible correction by subsequent scholars who credited any lack of sense in Cahen's edition and translation to lacunas in the original manuscript (Cahen, "Traité," 120, 142–43; Chevedden, "Citadel of Damascus," 298–301). I thank Emilie Savage-Smith for alerting me to Cahen's editorial error. Cahen translated Ṭarsūsī's description of the counterweight trebuchet as follows:

Description d'un mangonneau persan telle que me l'a faite le shaikh Abū 'l-Hasan b. al-Abraḳī al-Iskandarānī. La puissance de jet en est de cinquante *raṭl* environ; à la racine de son montant il y a une arbalète *jarkh*; le tout est actionné par un seul homme, qui fait le lancement: lorsque l'homme tire la flèche, les cordes de chanvre qui tendent la corde de l'arc atteignent son verrou; alors l'homme agence la cuiller dans un anneau fixé à un socle qui retient la flèche; puis il prend l'arc et en tire, puis dégage la flèche, ce qui produit le jet de la pierre.

Prends donc un mangonneau persan et dresse-le pour faire un lancement; creuse à côté du montant une cuvette dont la profondeur soit approximativement égale à la longueur des cordes de chanvre qui sont attenantes à la flèche; puis prends un filet de chanvre aux mailles étroites, et place à ses extrémités trois câbles de chanvre solide dont la longueur soit telle qu'ils aillent du sommet de la flèche, où est la truie, jusqu'au fond de la cuvette; qu'il y ait au bout de la flèche un anneau de fer auquel soient accrochés les câbles attachés au filet; et que dans le filet on place des pierres en quantité correspondant à la force des hommes qui tirent la flèche. Au bout de la flèche, à côté du câble de la cuiller, il doit y avoir un *mīkhān* placé dans une poulie pendue à la flèche; lorsque l'homme tire cette flèche, après avoir placé la pierre dans la cuiller, et accroché le câble de celle-ci au crochet placé au bout de la flèche, il [agence] la cuiller, à l'aide d'un crochet de fer placé en son fond, dans un anneau fixé à un socle, qui retient ainsi l'action du filet; [*lacune?*] sa corde avec les câbles qui soulèvent le filet dans un crochet fixé à ces câbles; et lorsque les câbles montent en soulevant le filet, [*lacune?* . . .] la flèche dans son conduit; il en tire, puis sur-le-champ revient à la cuiller et la déplace suivant son seul jugement.

Pour ce qui est de la traction, il y a diverses façons. Voici le dessin. On peut tirer le filet en tirant la tête de la flèche, puisque celle-ci revient comme une balance (romaine) et qu'une fois tirée elle est fixée. Quant à l'arc *jarkh*, il doit être placé à la base du pied du mangonneau dans deux crochets de fer qui le tiennent; on tire la corde de l'arc, et l'amène dans le verrou de son conduit. Lorsque l'homme a agencé la cuiller dans le socle, il saisit l'arc et le détend (?); le filet tire la flèche en la rappelant à sa position primitive, et la traction est plus forte que ne serait celle des hommes, car le filet tire selon sa proportion.

on Islamic civilization.⁶⁵ Donald Hill was so puzzled by the flawed text that he considered Ṭarsūsī's description of the counterweight trebuchet as "too confused for us to identify it for certain as a counterweight machine."⁶⁶ C. E. Bosworth may have been baffled as well, but that did not stop him from speculating about the design and function of the machine. He identified it as an arrow-projecting catapult. "The arrow or projectile," he argues, "is placed vertically on the left, a heavy counter-weight on the right." No arrow is shown in the illustration, and the crossbow of the machine is positioned facing downward. If Bosworth's arrow or projectile were positioned on the crossbow of the machine, it would be set facing the ground, not facing upward so that the missile might be hurled into the air. Bosworth mistook the actual projectile of the machine—the stone-shot in the sling—for the counterweight of the trebuchet.⁶⁷ José Frederico Finó also misunderstood the function of the machine by suggesting that the crossbow attached to it served as a kind of acceleration device to impart initial momentum to the beam during the first phase of the launch cycle.⁶⁸

Cahen's flawed text is not the only problem confronting those attempting to understand Ṭarsūsī's description of this machine. Even though the depiction of his machine is

⁶⁵B. Lewis, *Islam: From the Prophet Muhammad to the Capture of Constantinople*, 2 vols. (New York, 1974), 1:221–22. Lewis's English translation of Cahen's French rendition of Ṭarsūsī's description of the counterweight trebuchet reads:

Description of a Persian Mangonel, Made for Me by Shaykh Abu'l-Ḥasan ibn al-Abrāqī al-Iskandarānī, with a Throwing Power of Fifty Pounds More or Less

Its base is a crossbow [*jarkh*], and it is operated by a single man who makes the launch. When the man pulls the shaft, the hemp cords, which stretch the bowstring, reach its bolt; then the man catches the cup in a ring fixed to a strut which holds the shaft. Then he takes the bow and shoots and releases the shaft so that the stone is thrown.

Take a Persian mangonel and set it up to make a launch. Dig a hole by the side of the pole, to a depth equal to the length of the hemp cords on the shaft. Then take a close-meshed hemp net and place at its ends three strong hemp ropes, long enough to reach from the top of the shaft, where the axle is, to the bottom of the hole; at the end of the shaft there should be an iron ring, to which the ropes attached to the net are tied; and in the net stones should be placed in a quantity corresponding to the strength of the men who pull the shaft. At the end of the shaft, by the cup rope, there should be two nails placed on a windlass hanging from the shaft. When the man pulls this shaft, after having placed the stone in the cup and tied the cup rope to the hook placed at the top of the shaft, he . . . the cup with an iron hook placed at its end in a ring fixed to a strut which supports the action of the net . . . its cord with the ropes which raise the net in a hook fixed to the ropes, and when the ropes rise with the net . . . the arrow in its course. He shoots and then immediately returns to the cup and releases it according to his judgement. There are various ways of pulling it. Here is a picture of it. One may pull the net by pulling the top of the shaft, since it swings back like a steelyard and can be pulled and caught. The crossbow should be placed at the bottom of the strut of the mangonel, on two iron hooks which hold it. One draws the bow string and pulls it toward the bolt on its course. When the man catches the cup in the strut, he takes the bow and holds it so that the net pulls the shaft. He brings it back to its position. This traction is stronger than that of men, since the net draws according to its proportion.

⁶⁶Hill, "Trebuchets," 104. Hill later modified his original assessment of Ṭarsūsī's description of the counterweight trebuchet: "although the passage is obscure, it is possible that this was a counterweight machine" (D. R. Hill, "Mandjanik," *EP*, 6:405–6). Rogers declares the text a "confusing description of a counterweight lever device" (Rogers, *Latin Siege Warfare*, 263).

⁶⁷C. E. Bosworth, "Armies of the Prophet: Strategy, Tactics and Weapons in Islamic Warfare," in *The World of Islam: Faith, People, Culture*, ed. B. Lewis (London, 1976), 214–15 and fig. 4.

⁶⁸J.-F. Finó, "Machines de jet médiévales"; idem, *Forteresses*, 149–63.

very clear and is accompanied by explanatory caption titles, which have been properly edited by Cahen, the nature and function of his ingenious contrivance has proved elusive. The difficulties of understanding this machine are increased by the hybrid nature of the device. Ṭarsūsī depicts not one machine but two: a counterweight trebuchet and a large siege crossbow. In addition, the counterweight trebuchet itself performs two functions: it is both a stone-projector and a spanning device for a large siege crossbow. The wizardry of the machine is made even more compelling by the fact that it is operated by a single man. The author's interest in gravitational energy is not motivated by a realization that the fall of a large mass can exert more force than human traction-power. Gravity power is commended only because it exerts "a constant force, whereas men differ in their pulling force." The text clearly states that this machine has the same power as that of a traction trebuchet with a pulling-crew of about fifty men. Hence, Ṭarsūsī's counterweight trebuchet is comparable to a medium-size traction machine. Ṭarsūsī appears not to be a forward-looking visionary intent upon extolling the benefits of a new energy source, but a technical wizard who seeks to overawe his audience with a display of machine-magic: a multipurpose, laborsaving powered mechanism that requires only one person for its operation.

The hybrid nature of Ṭarsūsī's machine is further demonstrated by its retention of design features of the traction trebuchet: it is equipped with a short sling, similar to that of a traction machine, and it has no trough. Its retention of these features may even have been necessitated by its restriction to a single operator. Although the treatise in which this machine appears was written for Saladin around 1187, its description of the counterweight trebuchet is based on an account of a machine made for the author by an Armenian arms manufacturer, Shaykh Abū al-Ḥasan ibn al-Abraqī, who worked in Egypt earlier in the twelfth century (see App. 2).

Hence, Ṭarsūsī's counterweight trebuchet may not reflect artillery technology contemporary with Saladin's reign (1169–93), but of an earlier period. It may even be argued that Ṭarsūsī's idiosyncratic selection of material from his informant does not necessarily reflect the real advances made in the field of military engineering during the twelfth century. Both Ṭarsūsī and Ibn al-Abraqī (perhaps with Ṭarsūsī's prompting) show special interest in multipurpose weapons with little or no practical utility: several variations of a lance fitted with a crossbow are described and illustrated in the treatise, as well as a crossbow with a circular shield. Hence, Ṭarsūsī's counterweight trebuchet may reflect a Rube Goldberg tendency to produce an ingenious device that may never have found any practical use. It may not tell us much about the true progress being made in artillery design at the time the treatise was written. Nevertheless, Ṭarsūsī presents the only pictorial evidence for the existence of the counterweight trebuchet in the twelfth century.

New Terminology

In the twelfth century, the emergence of the counterweight machine is confirmed by the use of new terminology in the historical sources to refer to this piece of artillery. Arabic sources of the twelfth century identify the counterweight trebuchet as a "big" trebuchet (*manjanīq kabīr*), a "great" trebuchet (*manjanīq 'azīm*), or as a "huge" or "frightful" trebuchet (*manjanīq hā'il*). Syriac sources use the term "great" trebuchets (*manganīqē*

rawrbē) to denote counterweight artillery, as does Eustathios of Thessalonike (μεγάλη μηχανή, “great siege-engine”). In the Latin West, the new artillery is designated by the term *trebuchet*, a diminutive form derived from the medieval Latin word *trabuc[h]us*. The word first appears in 1189 as *trabuchellus*, following a standard diminutive construction, and later as *trabuchus* (see below and App. 1).⁶⁹

Scholars agree that the term *trebuchet* designates the new gravity-powered artillery. However, can we be certain that the other words that refer to “big,” “great,” and “huge” or “frightful” machines also denote the counterweight *trebuchet*? These terms may simply refer to oversized traction or hybrid *trebuchets*, not to counterweight *trebuchets*. The evolution of artillery nomenclature suggests, however, that this is not the case.

In the ninth century, the term “big” *trebuchet* (*manjanīq kabīr*) had been used in Arabic sources to denote the hybrid *trebuchet*. During this century, this new technical term appears only in the accounts of two sieges: the siege of Amorion in 223/838 and the siege of Baghdad in 251/865. Ṭabarī and the anonymous author of *Kitāb al-ʿuyūn wa-al-ḥadāʾiq* initially used a new term, *manjanīq kabīr*, to designate the hybrid *trebuchet*, but they then reverted back to the old term, *manjanīq*, to refer to the gravity-assisted machine. The term *manjanīq* had been used in Arabic sources to denote the trestle-framed traction *trebuchet* since the appearance of this machine in Arabia during the lifetime of Muḥammad. When the hybrid machine was introduced, *manjanīq* took on a broader meaning and referred to any type of trestle-framed *trebuchet*. The broad use of the term *manjanīq* does not reflect any reluctance on the part of Islamic societies to employ a new term for a new machine but rather the reluctance on the part of the educated elite writing the literary texts to recognize or employ new terminology. Arabic oral culture applied the term *al-Ghaḍbān* (The Furious One) to the hybrid *trebuchet*, but Arabic chroniclers ignored it.⁷⁰

The failure of the Arabic sources to identify the hybrid *trebuchet* with a change of appellation was in part due to the nature of the nomenclature for artillery. When the hybrid machine appeared, the terminology for the *trebuchet* was already established, and this terminology was related to the configuration of the framework of the machine, a component that remained unchanged regardless of whether the machine was a traction or a hybrid model. The hybrid machine made use of gravitational energy for the first time, amplifying the muscular force of the pulling crew. Although this led to a change in the operation of the *trebuchet*, it did not alter the configuration of the machine’s framework. Once the novelty of the hybrid *trebuchet* had worn off, the term *manjanīq* was applied to both models of the trestle-framed *trebuchet*, and the technical term “big” *trebuchet* (*manjanīq kabīr*) was no longer applied to it. After a three-century hiatus, this technical term emerged again. Its re-emergence is not likely to indicate the existence of familiar technology but the introduction of something new: the counterweight *trebuchet*. In addition, other terms were applied to artillery in the twelfth century that emphasized either great size or great power (see App. 1). This terminological change is reflected not

⁶⁹For references to counterweight *trebuchets* employed during the 12th century, see App. 1. For a discussion of the system of nomenclature for the *trebuchet* employed during the 13th century, see below and Chevedden, “Artillery of King James I,” 61–63, 68–76.

⁷⁰Ṭabarī, *Taʾriḫ*, 3:1247–48, also 1238, 1245; and *Kitāb al-ʿuyūn wa-al-ḥadāʾiq*, ed. M. J. de Goeje and P. de Jong (Leiden, 1871), 491; Chevedden, “Hybrid *Trebuchet*,” 188–90, 201.

only in Arabic, but also in Syriac and Greek, and clearly signals the emergence of new artillery, not the continuation of already existing forms.

Gravity-Powered Artillery in Siege Accounts of the Twelfth Century

The second siege of Tyre by the crusaders in 518/1124 provides the first instance of the counterweight trebuchet being identified by these new terms. The *Chronicle of 1234* speaks of the crusaders using “great trebuchets” (*manganīqē rawrbē*) and “many hybrid trebuchets” (*qalqūmē sagt’ē*) during this siege. The artillery breached the walls and destroyed many towers.⁷¹ William of Tyre’s account of the siege mentions that the crusaders sent to Antioch for an Armenian artillery expert named Havedic, who came to Tyre and “displayed so much skill in directing the machines and hurling the great stone missiles that whatever was assigned to him as a target was at once destroyed without difficulty.” With the aid of this Armenian specialist and his battery of artillery, the siege “assumed the aspect of a new war in the eyes of the Tyrians.” The crusaders pressed the siege with renewed strength, and the city was forced to surrender on 7 July 1124.⁷²

The fact that the crusaders drew upon native expertise during this siege for the operation of counterweight artillery suggests that they may have been in the process of assimilating this new technology at this time. The Armenian engineer who was employed to operate the artillery most probably acquired knowledge of gravity-powered artillery from the Byzantines, either directly or indirectly. The Byzantine Empire not only had the requisite power and wealth to develop and exploit new ideas in artillery design, it had a tradition of innovation that encouraged the development of new devices of mechanized siegecraft.

In 519/1125 Aq Sunqur al-Bursuqī, the Seljuq governor of Mosul, and the Bōrid Atabeg ʿTuḡtigin of Damascus battered the walls of ‘Azāz day and night with counterweight trebuchets, referred to as *manganīqē rawrbē* (great trebuchets).⁷³ In 532/1138, the Byzantine emperor John II Komnenos bombarded Shayzar with counterweight trebuchets, identified as *majānīq hā’ilah* (huge trebuchets) by Usāmah ibn Munqidh and as

⁷¹Anon., *Anonymi auctoris Chronicon ad annum Christi 1234 pertinens*, ed. J.-B. Chabot, CSCO, ser. 3, vol. 37, *Scriptores Syri* 15 (Paris, 1916), 94. Partially translated into English by A. S. Tritton, with notes by H. A. R. Gibb, “The First and Second Crusade from an Anonymous Syriac Chronicle,” *JRAS* (1933): 95; and partially translated into French by A. Abouna, with notes by J.-M. Fiey, CSCO, 354, *Scriptores Syri* 154 (Paris, 1974), 71. On Syriac terms for artillery, see Chevedden, “Hybrid Trebuchet,” 204–7, 219–22.

⁷²William of Tyre, *Historia rerum in partibus transmarinis gestarum*, 13.10, ed. R. B. C. Huygens (Turnhout, 1986); idem, *A History of Deeds Done Beyond the Sea*, trans. E. A. Babcock and A. C. Krey, 2 vols. (New York, 1943), 2:15. Rogers believes that Havedic’s expertise “was required, not for knocking down fortifications, but for directing counter-battery fire [*sic*],” and that “his specialty seems to have been accuracy rather than the use of heavy artillery” (Rogers, *Latin Siege Warfare*, 83, 242, 247 n. 22). France also believes that Havedic “was brought in to direct counter-fire [*sic*] at the defenders’ machines” (France, *Western Warfare*, 120). The crusaders may have requested the services of Havedic because defensive artillery was hampering their attack on the city, but William of Tyre emphatically states that Havedic hurled “great stone missiles” and “that whatever was assigned to him as a target was at once destroyed without difficulty.” Nowhere does he state that Havedic restricted his targets to enemy artillery. The artillery employed by Havedic doubtless knocked down fortifications. On Armenians and crusaders, see J. H. Forse, “Armenians and the First Crusade,” *JMedHist* 17 (1991): 13–22.

⁷³*Chronicle of 1234*, ed. Chabot, 98; Anon., *Anonymi auctoris Chronicon ad annum Christi 1234 pertinens*, trans. Abouna, 73; Tritton “Anonymous Syriac Chronicle,” 97.

majānīq ‘*izām* (great trebuchets) by Ibn al-‘Adīm. These machines hurled stone-shot weighing between 43 and 54.5 kilograms a minimum distance of 150 meters. Commenting on the power of the Byzantine artillery, Usāmah mentions that a single stone-shot discharged by one of the trebuchets destroyed a house and that the bombardment breached the wall of the fortress.⁷⁴

In 551–552/1157 the Seljuq sultan Muḥammad II, reacting to a resurgence of ‘Abbasid power in Iraq, bombarded Baghdad with two counterweight trebuchets, identified as *manjanīqayn* ‘*azīmayn* (great trebuchets).⁷⁵ The Normans used three counterweight trebuchets, termed *majānīq kibār* (big trebuchets), in their abortive attack on Alexandria in late July of 1174. These machines bombarded the city with black stones transported from Sicily especially for this purpose. A Muslim sally in force destroyed three large cat-castles advanced against the city, and a successful night attack and the imminent approach of Saladin’s army forced the Normans to withdraw after a three-day siege.⁷⁶

In 572/1176 Saladin utilized counterweight trebuchets, identified as *al-manjanīqāt al-kibār* (big trebuchets), at the siege of Maṣyāf. Because of nearby crusader activity, Saladin was unable to prosecute the siege and settled for a negotiated peace settlement.⁷⁷ ‘Imād al-Dīn’s account of Saladin’s siege of Āmid in 579/1183 identifies all three types of trebuchets in use in the twelfth century: the pole-framed trebuchet (‘*arrādah*), the trestle-framed traction trebuchet (*manjanīq*), and the trestle-framed counterweight trebuchet, identified as a “huge trebuchet” (*manjanīq hā’il*). The counterweight machine used in this

⁷⁴Usāmah ibn Munqidh, *Kitāb al-i’tibār*, ed. Qāsim al-Sāmarrā’ī (Riyadh, 1987), 134; Kamāl al-Dīn ‘Umar ibn Aḥmad Ibn al-‘Adīm, *Zubdat al-ḥalab min ta’rikh Ḥalab*, ed. Sāmī al-Dahhān, 3 vols. (Damascus, 1954), 2:268. Usāmah ibn Munqidh states that the Byzantine forces under emperor John II Komnenos set up trebuchets which hurled stone-shot weighing between 20 and 25 *raṭls* a distance farther than a bow-shot. Since Usāmah was a native of Shayzar, the measure of weight that he utilized was most probably the Shayzar *raṭl*, which was equivalent to 2.137 kilograms (W. Hinz, *Islamische Masse und Gewichte* [Leiden, 1970], 31). The weight of the stone-shots launched by the Byzantine army was, therefore, between 43 and 54.5 kilograms (94–120 pounds). The information provided by Usāmah also allows us to gauge the distance of the launch of the stone-shot. If the projectiles were hurled farther than a bow-shot, this distance would probably be beyond the effective range of a military, rather than a sporting, bow. According to Marsden, the maximum effective range of a composite bow for military purposes was in the region of 150 to 200 yards (137–183 m) (Marsden, *Greek and Roman Artillery: Historical Development*, 12). Denys Pringle, utilizing information contained in Maurice’s *Strategicon*, estimates the maximum effective range of a bow-shot to be 140 meters (*The Defence of Byzantine Africa from Justinian to the Arab Conquest*, 2 vols. [Oxford, 1981], 1:150). Considering that the Byzantine trebuchets hurled stone-shot beyond the range of a bow-shot, the distance reached by these stones would probably have been at least 150 meters and most probably closer to the 200-meter mark or beyond.

⁷⁵Bundārī, *Zubdat al-nuṣrah*, 249.

⁷⁶‘Imād al-Dīn Muḥammad ibn Muḥammad al-Kātib al-Isfahānī, *Kitāb al-fayh al-qussī fī al-faṭḥ al-Qudsī*, ed. C. de Landberg (Leiden, 1888), 227–28; idem, *Sanā al-Barq al-Shāmī*, 562/1166–583/1187, abridged by al-Faṭḥ ibn ‘Alī al-Bundārī, ed. Faṭḥiyah al-Nabarāwī (Cairo, 1979), 76–79; ‘Abd al-Rahmān ibn Ismā‘īl Abū Shāmāh, *Kitāb al-rawḍatayn fī akhbār al-dawlatayn*, ed. M. H. M. Aḥmad and M. M. Ziyādah (Cairo, 1962), 1.2:598–600; ‘Alī ibn Muḥammad Ibn al-Athīr, *al-Kāmil fī al-ta’rikh*, ed. C. J. Tornberg, 13 vols. (Beirut, 1965), 11:412–14; Bahā’ al-Dīn Yūsuf ibn Rāfi’ Ibn Shaddād, *al-Nawādir al-sultānīyah wa-al-mahāsīn al-Yūsufīyah*, ed. Jamāl al-Dīn al-Shayyāl (Cairo, 1964), 48–49; Jamāl al-Dīn Muḥammad ibn Sālim Ibn Wāṣil, *Mufarrij al-kurūb fī akhbār Banī Ayyūb*, ed. Jamāl al-Dīn al-Shayyāl, S. A. F. ‘Ashūr, and H. M. Rabī’, 5 vols. (Cairo, 1953–), 2:11–16; A. S. Ehrenkreutz, *Saladin* (Albany, 1972), 124–25; M. C. Lyons and D. E. P. Jackson, *Saladin: The Politics of the Holy War* (Cambridge, 1982), 76–77; Rogers, *Latin Siege Warfare*, 120–21; Y. Lev, *Saladin in Egypt* (Leiden, 1999), 164.

⁷⁷Kātib al-Isfahānī, *Sanā al-Barq al-Shāmī*, 105–6; Abū Shāmāh, *Rawḍatayn*, 669–70; Ibn al-Athīr, *Kāmil*, 11:436; Ibn Wāṣil, *Mufarrij*, 2:47–48; Ehrenkreutz, *Saladin*, 152; Lyons and Jackson, *Saladin*, 108–9.

siege was given the name *al-Mufattish* (The Examiner), indicating that this piece of artillery was treated with special regard. Heavy bombardment and mining over a three-day period discouraged resistance and led to a negotiated settlement, by which Saladin gained possession of the city and Ibn Nisān withdrew with his possessions.⁷⁸

Saladin employed a total of nine *al-manjanīqāt al-kibār* at the siege of Kerak in Jumādā I 580/August 1184. These machines delivered an around-the-clock bombardment, while three digging-mantlets were constructed across the deep ditch on the eastern front of the fortress to dismantle the castle wall. Filling-mantlets were also employed to protect men engaged in filling up the ditch in preparation for an escalade. Saladin was on the verge of taking the castle when a Frankish relief force moved on Kerak and forced him to withdraw.⁷⁹

To capture Thessalonike in 1185 the Normans bombarded the city with a number of counterweight trebuchets. Eustathios, the archbishop of the city, admiringly describes the artillery employed by the Normans and explains their siege tactics. On the western side of the city, the Normans “moved up newly invented heavy artillery (*helepoleis*).” These machines, Eustathios tells us, “did not perform brilliantly because they were difficult to manage due to their large size.” On this side of the city, the Normans appear to have attempted an attack using massed heavy artillery to breach the fortifications. The contrast drawn by Eustathios between the siege techniques employed on the western side of the city with those used on the eastern side supports this conjecture. On the eastern side, Eustathios tells us that the Normans “concentrated on more conventional methods” of siegecraft. Here, artillery was used to neutralize the defense while mining operations effected a breach in the city wall. A battery of trestle-framed trebuchets (μηχανὰς πετροβόλους, *mēkhanas petrobolous*), “most of them of small size,” bombarded defensive artillery mounted on the city walls and “caused damage to the city with their accurate aim,” while a pair of larger trebuchets tore away the battlements and caused severe damage to the interior of the city.

One of the two larger trebuchets on the eastern side of the city was called “The Daughter of the Earthquake” (σεισμοῦ θυγάτηρ, *seismou thygatēr*) because its missiles impacted with such violence. On two occasions, Eustathios refers to this machine, or perhaps its mate, as “the great siege-engine” (*megalē mēkhanē*) and once as “their largest siege-engine” (μεγίστη μηχανή, *megistē mēkhanē*). The projectiles that it discharged were so heavy—“fully as much as a man could lift”—that Eustathios likened the barrage of missiles flung by the smaller *petroboloi* to “the efforts of children compared with those hurled by the great siege-engine.” Eustathios was so fond of his comparison of the smaller pieces of artillery to children that he called the “great” trebuchet “Their Mother” (τὴν μητέρα, *tēn mētera*). The commander of the city had another name for this powerful piece of

⁷⁸ Imād al-Dīn Muḥammad ibn Muḥammad al-Kātib al-Isfahānī, *al-Barq al-Shāmī*, ed. Fāliḥ Ḥusayn (Amman, 1987), 5:85; idem, *Sanā al-Barq al-Shāmī*, 218–21; Abū Shāmāh, *Rawḍatayn*, 2:38–42; Ibn Shaddād, *Nawādir*, 58; Ibn al-Athīr, *Kāmil*, 11:493–94; Ibn Wāṣil, *Mufarrij*, 2:134–36; Ehrenkreutz, *Saladin*, 180–81; Lyons and Jackson, *Saladin*, 190–91.

⁷⁹ Kātib al-Isfahānī, *Sanā al-Barq al-Shāmī*, 241–43; Ibn al-Athīr, *Kāmil*, 11:506–7; Abū Shāmāh, *Rawḍatayn*, 2:54–56; Ibn Shaddād, *Nawādir*, 66; Ibn al-Adīm, *Zubdah*, 3:78–79; Ibn Wāṣil, *Mufarrij*, 2:157–60; Ehrenkreutz, *Saladin*, 184; Lyons and Jackson, *Saladin*, 217–18; M. Barber, “Frontier Warfare in the Latin Kingdom of Jerusalem: The Campaign of Jacob’s Ford, 1178–79,” in *The Crusades and Their Sources. Essays Presented to Bernard Hamilton*, ed. J. France and W. G. Zajac (Aldershot, 1998), 9–22.

artillery: “The Old Woman” (γρᾱῖα, *graia*). As stones rained down upon Thessalonike, the dispirited commander cried out impassively, “Listen to the Old Woman,” and now and then he was heard to mutter, “The Old Woman is getting tired.”

The use of heavy artillery, on its own, along the western side of the city to batter the defenses strongly suggests that the Normans attempted an artillery assault to breach the wall. The *helepoleis* used in this operation, identified by Eustathios as newly invented, were doubtless counterweight trebuchets. On the eastern side of the city, the Normans tested defenses that were “not free of defects” and “not well maintained” with conventional siege techniques. Artillery provided a continuous barrage while the besiegers filled in the ditch, demolished the outer wall, and undermined the main wall. The battery of artillery on the eastern side of the city included only two large trebuchets. These machines were most likely counterweight trebuchets, and one of them, judging from the attention Eustathios devotes to it, was an especially large and powerful stone-projector.⁸⁰

In September 1187, Saladin besieged Jerusalem with counterweight trebuchets, identified by Bar Hebraeus as *manganīqē rawrbē* (“great trebuchets”).⁸¹ According to the Old French continuation of William of Tyre, one of Saladin’s trebuchets (*perriere*) discharged three shots against the city in a single day. Such a restrained performance is indicative of a counterweight trebuchet, which has a much slower sequence of discharge than the traction or the hybrid machine. The account also mentions that among the trestle-framed and pole-framed trebuchets (*perrieres et mangoniaus*) that Saladin set up were eleven large ones. The great size of these eleven machines suggests that they were counterweight trebuchets.⁸²

In Saladin’s most ambitious siege operation, against Tyre from 12 November 1187 to 1 January 1188 (9 Ramaḍān–29 Shawwāl 583), pole-framed and trestle-framed trebuchets (*ʿarrādāt* and *manjanīqāt*) were employed, according to Bundārī’s abridgement of *al-Barq al-Shāmī*. ʿImād al-Dīn’s more detailed account of the siege in his *Faṭḥ al-Qudsī* cites the use of trestle-framed traction and counterweight trebuchets (*al-majānīq al-ṣighār wa-al-kibār*). The Frankish fleet in Tyre made a nocturnal attack on the Muslim vessels that blockaded the harbor, capturing some ships and putting the rest to flight. This setback, coupled with the difficulties of a winter siege campaign and lack of enthusiasm in the Muslim camp to press the siege, forced Saladin to withdraw.⁸³

⁸⁰Eustathios, Archbishop of Thessalonike, *The Capture of Thessaloniki*, trans. J. R. Melville Jones (Canberra, 1987), 72–99. Huuri speculated that the Norman siege of Thessalonike in 1185 may have witnessed the first use of the counterweight trebuchet, but Rogers judged the evidence for this conjecture to be inconclusive (Huuri, “Geschützwesen,” 91–92; Rogers, *Latin Siege Warfare*, 121–23).

⁸¹Gregorius Bar Hebraeus, *Makhtebhānūth Zabhnē*, ed. P. Bedjan (Paris, 1890), 375; idem, *The Chronography of Gregory Abūʾl Faraj, the Son of Aaron, the Hebrew Physician, Commonly Known as Bar Hebraeus*, trans. E. A. W. Budge (London, 1932), 1:325.

⁸²M. R. Morgan, ed., *La Continuation de Guillaume de Tyr (1184–1197)*, Documents relatifs à l’histoire des croisades publiés par l’Académie des Inscriptions et Belles-Lettres 14 (Paris, 1982), 64–65: “Le jor que Saladin se remua de la Porte David et vint a la porte Saint Estiene, celui jor fist adrecier une perriere qui geta .iij. feis as murs de la cité. Et la nuit fist adrecier tant de perrieres et de mangoniaus que l’endemain en trouva l’en .xj. tous grans et getant as murs de la cité.” For an English translation of this text, see P. W. Edbury, *The Conquest of Jerusalem and the Third Crusade: Sources in Translation* (Aldershot, 1996), 56.

⁸³Kātib al-Isfahānī, *Sanā al-Barq al-Shāmī*, 317–23; idem, *Faṭḥ al-Qudsī*, 73–86, 110; Ibn al-Athīr, *Kāmil*, 11:553–55; Abū Shāmah, *Rawḍatayn*, 2:119–120; Ibn Shaddād, *Nawādir*, 83–84; Ibn Wāṣil, *Mufarrij*, 2:242–45; Ibn al-ʿAdīm, *Zubdah*, 3:100; Ehrenkreutz, *Saladin*, 206–8; Lyons and Jackson, *Saladin*, 279–83.

The Crusader Siege of Acre (585–587/1189–91)

An abundance of information on artillery is provided in the accounts of the siege of Acre by the crusaders (12 Rajab 585–17 Jumādā II 587/26 August 1189–12 July 1191). Scholars examining this siege for evidence of the use of gravity-powered artillery have been unable to determine with certainty that such artillery was employed.⁸⁴ I would argue, however, that the vocabulary used for heavy artillery in the sources and descriptive details that are provided of the machines confirm the use of counterweight trebuchets. ‘Imād al-Dīn mentions that the garrison of the city launched a sally in force on 1 Sha‘bān 586/3 September 1190 that destroyed two counterweight trebuchets (*manjanīqayn kabīrayn*) of Henry of Champagne, one costing 1,500 dinars.⁸⁵ Ibn Shaddād records the same event but states that one of the counterweight trebuchets was much bigger than the other. He identifies the large machine costing 1,500 dinars as “a big trebuchet of great magnitude” (*manjanīq kabīr ‘azīm al-shakl*) and the other as a trestle-framed trebuchet (*manjanīq*).⁸⁶ Later during the month of Sha‘bān/September, Ibn Shaddād records that two fire-arrows shot from a large crossbow set fire to two pieces of artillery, both identified as “huge trebuchets” (*manjanīqāt hā’ilah*), indicating that these machines were both counterweight trebuchets.⁸⁷

The *Itinerarium Peregrinorum et Gesta Regis Ricardi* describes a powerful and very effective trebuchet used by Acre’s defenders against the trebuchets of Henry of Champagne:

There were plenty of trebuchets [*petrariae*] in the city, but one of them was unequalled for its massive construction and its effectiveness and efficiency in hurling enormous stones. Nothing could stand against the power of this machine. It hurled huge stone-shot: “violent action, far-hurled stones; the blow smashed everything, whatever it struck.” If the stones met no obstruction when they fell, they sank a foot deep into the ground. This machine struck some of our trebuchets and smashed them to pieces or at least rendered them unusable. Its shots also destroyed many other siege machines, or broke off what it hit. It shot with such force, and its blows were so effective, that no material or substance could withstand the unbearable impact without damage, no matter how solid or well-built it was.⁸⁸

⁸⁴ Rogers, *Latin Siege Warfare*, 227, 234.

⁸⁵ Kātib al-Isfahānī, *Faṭḥ al-Qudsī*, 282.

⁸⁶ Ibn Shaddād, *Nawādir*, 134–35.

⁸⁷ Ibid., 136; Abū Shāmāh, *Rawḍatayn*, 2:162; Ibn Wāsil, *Mufarrij*, 2:335.

⁸⁸ Ricardus, *Itinerarium*, ed. Stubbs, 1:98: “Petrariarum hostilium, quarum fuit in civitate copia, una fuit incomparabilis, et magnitudine compactae machinae, et pro voto torquentium, inaestimabilis molis lapides jaculando efficax. Hujus nihil potuit resistere vehementiae. Incredibilis quippe molis lapides jaciebat;

Emissos etiam lapides procul impetus egit,
Omnia comminuit jactus quaecunque feriret.

Lapides nihilominus, quoties nullo retardarentur obstaculo, unius pedis longitudine agebantur in terram cadentes. Nonnullas petrariarum nostrarum percutiens in particulas dispersit, vel certe inutiles effecit; machinas quoque alias plures vel ictu dissolvit, vel particulam quam attigerat abscidit. Tanta nimirum erat vehemens entia jaculandi, et impetus tam pertinax, quod nihil tam solidum, vel ita fuit compactum, cujuscunque materiae vel substantiae, quod posset incolume tam intolerabilis percussurae sustinere injuriam.” The translation of this passage is taken from Nicholson, *Chronicle of the Third Crusade*, 103, with the following changes: the term *petrariae* is translated as “trebuchets” (not “stonethrowers”), the phrase *molis lapides* in the second sentence is rendered “huge stone-shot” (not “really incredible lumps of rock”); and the verb *jaculor* is translated as “to shoot” (not “to fire”). Cf. Ambroise, *Estoire*, vv. 3535–60.

The Muslim trebuchet was doubtless a counterweight machine. Features that characterize this ordnance—pinpoint accuracy and great power—are highlighted in the Latin account of it. The Anglo-Norman poet known as Ambroise describes the same machine but adds an important detail that confirms that it is gravity-powered. He states that “all of two men’s strength it took to draw its sling.”⁸⁹ The drawing of the sling refers to the pulling or stretching out of the sling to its full length in preparation for launch. Fixed to the bedplate of the counterweight trebuchet is a trough, placed on the same vertical plane as the throwing arm. This device serves as a runway for the projectile during the initial phase of the launch cycle. Once the beam has been wound back to its launch position, the sling is stretched out along the trough, and the projectile is loaded into the pouch of the sling. At the completion of this operation, the machine is ready for discharge (Figs. 2 and 3).

The destructive effects of the artillery bombardment against Acre, particularly during the final stages of the siege, indicate that most of the machines described in the historical accounts were counterweight trebuchets. The *Itinerarium Peregrinorum*, which provides a detailed description of eleven trebuchets deployed by the crusaders against the Maledicta Tower and its adjacent walls in June and July of 1191, is worth quoting at length:

The king of France . . . concentrated on constructing siege machines and placing trebuchets [*petrariae*] in suitable places. He arranged for these to shoot continually day and night. He had one excellent one which he called “Bad Neighbor” [*Malvoisine*] [1]. The Turks in the city had another which they called “Bad Relation” [*Mal Cousine*] and often used to smash “Bad Neighbor” with its violent shots. The king kept rebuilding it until its continual bombardment partly destroyed the main city wall and shattered the Cursed Tower. On one side the duke of Burgundy’s trebuchet [2] had no little effect. On the other the Templars’ trebuchet [3] wreaked impressive devastation, while the Hospitallers’ trebuchet [4] also never ceased hurling, to the terror of the Turks.

Besides these, there was a trebuchet that had been constructed at general expense, which they called “God’s Stone-Thrower” [5]. A priest, a man of great probity, always stood next to it preaching and collecting money for its continual repair and for hiring people to gather the stones for its ammunition. This machine at last demolished the wall next to the Cursed Tower for around two perches’ length [11 yards or 10 meters].

The count of Flanders had had a choice trebuchet [6], which King Richard had after his death, as well as another trebuchet [7] which was not so good. These two constantly bombarded the tower next to a gate which the Turks frequently used, until the tower was half-demolished. Besides these, King Richard had two new ones made [8 and 9] with remarkable workmanship and material which would hit the intended target no matter how far off it was. . . . He also had two mangonels [traction trebuchets] [10 and 11] prepared. One of these was so swift and violent that its shots reached the inner streets of the city meat market.

King Richard’s trebuchets hurled constantly by day and night. It can be firmly stated that one of them killed twelve men with a single stone. That stone was sent for Saladin to see, with messengers who said that the diabolical king of England had brought from Messina, a city he had captured, sea flint and the smoothest stones to punish the Saracens. Nothing could withstand their blows; everything was crushed or reduced to dust.⁹⁰

⁸⁹ Ambroise, *Estoire*, vv. 3545–46: “Que dous genz covenit a metre // En la funde” (*The Crusade of Richard Lion-Heart*, trans. M. J. Hubert with notes and documentation by J. L. La Monte, Records of Civilization, Sources and Studies 34 [New York, 1941], 160).

⁹⁰ Ricardus, *Itinerarium*, ed. Stubbs, 1:218–19: “Rex Franciae . . . machinis intendebat conficiendis, et petrariis locis aptis applicandis, quas et nocte dieque incessabiliter instituit jaculari. Quarum unam habuerat

Arabic sources provide details of Philip II's artillery assault against Acre launched on 4 Jumādā I 587/30 May 1191. He employed seven trebuchets (*majānīq*) that caused considerable damage to the walls before Muslim defenders were able to destroy the machines. Burj 'Ayn al-Baqar (Maledicta Tower) sustained heavy damage in this attack.⁹¹

Philip II and Richard I joined together for a massive artillery assault against Acre in June–July 1191 (Jumādā I–Jumādā II 587). According to 'Imād al-Dīn, the crusaders "brought every type of trebuchet (*manjanīq*) as large as a mountain" against the city. "They set up thirteen trebuchets (*manjanīq*) in one place," he recounts, "and stones brought down the wall, with each stone more of it." The outer wall was destroyed and the main wall was breached. 'Imād al-Dīn recounts that the walls were reduced to an elevation "no higher than a man's height." His final damage assessment details the devastation: "They [the crusaders] engaged in the discharge of trestle-framed trebuchets [*manjanīqāt*], the erecting of siege machines and pole-framed trebuchets [*arrādāt*], and the loading of stones until the wall was on the verge of destruction. The walls were shaken loose, breaches were visible, and the curtains were demolished."⁹² Ibn Shaddād's account echoes 'Imād al-Dīn's description: "Trebuchets [*manjanīqāt*] destroyed the walls to no higher than a man's height. Trebuchets [*manjanīqāt*] pounded the walls continually until the stones became detached."⁹³

The historical sources offer compelling evidence for the use of counterweight trebuchets at the siege of Acre. The technical vocabulary used in the Arabic sources for the artillery at Acre offers very strong evidence for the machine's use, as do the operational details provided by Ambroise that are specific to counterweight artillery and the degree of damage inflicted by artillery bombardment in this siege.

Trebuchet and Its Cognates

In the Latin West, the term *trabuchellus* first appears in a fealty document issued in Vicenza on 6 April 1189. In this document, villagers in the region of Vicenza profess

peroptimam quam vocavit Malam Vicinam. Turci vero infra civitatem alteram habebant quam vocabant Malam cognatam, quae vehementibus jactibus frequentius dissipare solebat Malam Vicinam: quam rex reaedificabat, quousque jugiter jaciendo, principalem civitatis murum in parte diruit, et Turrim Maledictam conquassavit. Hinc et petraria ducis Burgundiae non in vanum jaciebat: illinc Templariorum petraria Turcos vastabat egregie, et Hospitalariorum quoque Turcis metuenda nequaquam cessabat a jactibus. Praeter has quoque fuit quaedam petraria, communicatis impensis compacta, quam vocitabant petrariam Dei. . . . Per ipsam demum ad aestimationem duarum perticarum, juxta turrim Maledictam, conquassatus est murus. Comes Flandriae petrariam habuerat electam, quam post ejus mortem habuit rex Ricardus, et praeterea minorem electam. Hae duae sine intermissione jaciebant versus turrim juxta portam quandam, quam Turci frequentabant, donec turris medietatem diruerunt. Et praeter has, facerat rex Ricardus alias novas duas, operis electi et materiae, ineffabiliter destinatae percutientes quorumcunque metam locorum. . . . Duos etiam praeparaverat mangunellos quorum unus tantae fuerat agilitatis et vehementiae, quod jactus ejus pervenirent in interiores macelli civitatis plateas. Petrariae itaque regis Ricardi die noctuque jugiter jaciebant, de quarum una certissime constat, quod unius lapidis jactu prostraverit in mortem duodecim homines." The translation of this passage is taken from Nicholson, *Chronicle of the Third Crusade*, 208–9, with the following changes: the term *petraria* is translated as "trebuchet" (not "stonethrower"), and the verb *jaculor* is translated as "to shoot" (not "to fire"). Cf. Ambroise, *Estoire*, vv. 4741–4808.

⁹¹ Kātib al-Isfahānī, *Fath al-Qudsī*, 330–35; Ibn Shaddād, *Nawādir*, 158–60; Ibn al-Athīr, *Kāmil*, 12:64; Abū Shāmāh, *Rawdatayn*, 2:184; Ibn Wāṣil, *Mufarrij*, 2:350.

⁹² Kātib al-Isfahānī, *Fath al-Qudsī*, 345, 346, 349, 350, 366.

⁹³ Ibn Shaddād, *Nawādir*, 165–66.

fealty to the city and pledge among other things “not to transport a mangonel, a trebuchet, a *petraria*, a crossbow or a bow, or permit anyone to do so . . . up to the boundary of its [Vicenza’s] consulate.”⁹⁴ A decade later, the standard nominal form *trabuchus* is used. In October 1199, the Cremonans besieged Castelnuovo Bocca d’Adda with *petrariae* and trebuchets (*trabuchi*).⁹⁵ The origin and precise meaning of trebuchet is a subject of uncertainty among scholars. The conventional etymology of *trabuc[h]us* (OF. *trabuc*, *trebuc*, and *triboc*; Cat. *trabuc*; Cast. *trabuco*; It. *trabucco*; Ger. *driboc[k]*, *tripoch*, or *triboc*; and OE. *trabuch*) suggests that the term is derived from the Latin prefix *trans-*, expressing displacement, and the Old French word *buc*, referring to a trunk (of a body).⁹⁶ This etymology infers that the word is related to the machine’s operation rather than to its shape or structural configuration—the trunk (of a body) being displaced or discharged by the machine. But since the machine generally throws stones, this etymology is unlikely, even if *buc* can be interpreted allegorically to refer to any large projectile.

An etymology related to the form of the machine appears to be more plausible than one related to its function. Such an etymology is readily apparent. The first part of the word is the prefix *tri-* (three), and the second part is the Latin noun *bracchium* (arm) or its cognates in medieval Latin (*bracco*), romance languages, or German. A *tribracchium*, or *tribracho*, literally means a device having three arms or branches. The trestle-framed trebuchet probably received this designation because its three main components were conceived of as being three large arms: a beam (one arm) pivoting on an axle that was supported by two triangulated trusses (the second and third arm) forming the trestle frame. The description of trestle-framed hybrid trebuchets by Abbo of Saint-Germain-des-Prés at the siege of Paris in 885–886 confirms that Europeans of the Middle Ages did reduce the machine to its three main components: a throwing arm and the trusses of the trestle frame.⁹⁷ The *Chronicon Sampertrinum* supports the derivation of trebuchet from *tribracchium* by equating a *tribracho* with a *tribock* in its description of the campaign of Emperor Otto IV in Thuringia in 1212: “Otto, having come into Thuringia, besieged and reduced the castle of the Landgrave at Salza with a trebuchet (*tribracho*) called a *tribock*.”⁹⁸

⁹⁴ Giambasta Verci, *Storia degli Ecelini*, 3 vols. (Brassano, 1779), 3:97: “nec unum mangano nec trabuchello aut cum prederia vel balista vel archu traham nec aliquem trahere permittam nec faciam si vetare potero usque ad finem sue consularie.” I thank Donald J. Kagay for translating this passage.

⁹⁵ Giovanni Codagnello, *Iohannis Codagnelli Annales Placentini*, ed. O. Holder-Egger, MGH, *ScriptRerGerm* (Hanover-Leipzig, 1901), 25: “Cremonenser . . . quoddam fossatum munierunt cariolis, quas posuerunt super ripam illius, et gladiis et beltreschis et predariis et trabuchis.”

⁹⁶ *Oxford English Dictionary*, s.v. “trabuch”; A. J. Greimas, *Dictionnaire de l’ancien français jusqu’au milieu du XIV^e* (Paris, 1968), 639.

⁹⁷ Abbo, *Le Siège de Paris par les Normands*, 1.360–67, ed. and trans. H. Waquet (Paris, 1942), 42–43; Chevedden, “Hybrid Trebuchet,” 196–98.

⁹⁸ *Chronicon Sampertrinum*: “Otto veniens in Thuringiam cum tribracho illo, cognomento tribock, castrum lantgravii in Salza obsedit et expugnavit,” quoted in R. Schneider, *Die Artillerie des Mittelalters* (Berlin, 1910), 28. In 1212 the *Annales Marbacenses* records Otto’s subsequent use of the *tribok* following the siege of Salza. *Annales Marbacenses*, ed. H. Bloch, MGH, *ScriptRerGerm* 9 (Hanover, 1907), 81–82: “Et inde [from Salza] progrediens obsedit oppidum Wizense quod similiter expugnavit usque ad arcem. Ibi tunc primo cepit haberi usus instrumenti bellici, quod vulgo tribok appellari solet” (From Salza he advanced to besiege Weissensee which he similarly reduced. There was used for the first time that war engine which is commonly called the *tribok*). Trans. P. Contamine, *War in the Middle Ages*; trans. M. Jones (Oxford, 1984), 104. The medieval Latin verb *trabucare* (to bombard) and its romance cognates are derived from *trabuchus* (J. F. Niermeyer, *Mediae latinitatis lexicon minus* [Leiden, 1976], 1034).

The term trebuchet (OF. *trebuchet*, also *trebuket*, *trebusket*, *trabuchet*; Prov. *trabuquet*; Cat. *trabuquet*; Cast. *trabuquete*; It. *trabocchetto*; med. L. *tra-*, *trebuchetum*) is the diminutive form of *trabuchus*. Because the diminutive form is used, some have argued that the trebuchet must have been a smaller machine than the *trabuchus*. France even contends that a number of historical sources indicate that the term *trebuchet* denotes a “light weapon altogether.”⁹⁹ The counterweight trebuchet is, however, the largest artillery weapon of its class. Villard de Honnecourt’s massive trestle-framed trebuchet is estimated to have had a counterweight weighing 30 tons.¹⁰⁰ Clearly, there must be some other reason, unrelated to size, that explains the use of a diminutive form to designate such an enormous machine. If it does not arise from irony, it may have been used to domesticate the terror of the new weapon. J. R. Hale has suggested this explanation as the reason behind the naming of cannon in the era of early gunpowder weaponry, and it seems to be equally applicable to the era of pre-gunpowder artillery.¹⁰¹ This is a very human response to the destructive power of new weaponry and can be seen in our own day in the naming of nuclear devices, such as “Little Boy” that destroyed Hiroshima.¹⁰²

The Catalan Grand Chronicles shed light on this question. The chronicles of King James I of Aragon-Catalonia (1208–76) and Bernat Desclot always employ the term *trabuquet* (or *trebuquet*), never *trabuc*,¹⁰³ whereas the chronicles of Ramon Muntaner and King Peter IV of Aragon (III in Catalonia) (1336–87) always use the term *trabuc*, never *trabuquet*.¹⁰⁴ Three of the four chroniclers—James, Desclot, and Muntaner—describe the siege of the city of Majorca (modern Palma) in 1229 by King James. While the accounts of this siege by James and Desclot are very detailed and make abundant references to the use of *trabuquets* by both besieger and besieged,¹⁰⁵ Muntaner’s account is abbreviated and has only one reference to the Muslims’ siege machines, identified as *trabucs*.¹⁰⁶ This appears to indicate that there was no difference between these machines; the Catalan chroniclers simply used the terms interchangeably.

If this supposition is correct, the machine designated as the *trabuquet* (= trebuchet) corresponds to the *trabuc*; both terms refer to a trestle-framed gravity-driven machine. Some scholars argue that the trebuchet can be further defined structurally. Joseph Goday y Casals and Jordi Bruguera believe that the trebuchet had a hinged counterweight.¹⁰⁷

⁹⁹W. Giese, “Waffen nach den katalanischen Chroniken des XII. Jahrhunderts,” *Volkstum und Kultur der Romanen* 1 (1928): 147; J. France, *Western Warfare in the Age of the Crusades, 1000–1300* (Ithaca, 1999), 122.

¹⁰⁰Bechmann, *Villard de Honnecourt*, 265.

¹⁰¹J. R. Hale, “Gunpowder and the Renaissance: An Essay in the History of Ideas,” in *From the Renaissance to the Counter-Reformation. Essays in Honor of Garrett Mattingly*, ed. C. H. Carter (New York, 1965), 131.

¹⁰²H. Jaffe, “What’s in a Name? Just a Funny Little Nuke Test,” *Los Angeles Times*, 8 August 1983.

¹⁰³James I, King of Aragon, *Llibre dels fets del rei En Jaume*, ed. J. Bruguera, 2 vols. (Barcelona, 1991), 2:69.3, 69.5, 69.9, 69.11, 69.13, 69.15, 69.18, 69.25, 69.44, 69.46, 125.10, 126.5, 126.13, 157.13, 157.20, 158.4, 194.25, 262.4; Bernat Desclot, *Crònica de Bernat Desclot*, in *Les quatre grans cròniques, Jaume I, Bernat Desclot, Ramon Muntaner, Pere III*, ed. F. Soldevila (Barcelona, 1971), chaps. 39, 40, 42, 49, 110, 118.

¹⁰⁴Ramon Muntaner, *Crònica de Ramon Muntaner*, in Soldevila, *Les quatre grans cròniques* (as above, note 103), chaps. 7, 44, 93, 107, 165, 169, 223, 229, 246, 258, 259, 272; Peter IV of Aragon (III in Catalonia), *Crònica de Pere el Cerimoniós*, in *ibid.*, chaps. 1.11, 1.16, 5.32, 6.23, 6.24.

¹⁰⁵James I, *Llibre dels fets*, chaps. 69, 157, 158; Bernat Desclot, *Crònica*, chaps. 39, 40, 42.

¹⁰⁶Ramon Muntaner, *Crònica*, chap. 7.

¹⁰⁷Joseph Goday y Casals, “Medis d’atach y de defensa en la Crònica del Rey D. Jaume,” in *Congrés d’historia de la corona d’Aragó, dedicat al rey En Jaume I y a la seua época*, 2 vols. (Barcelona, 1909–13), 2:803; J. Bruguera, “Vocabulari militar de la Crònica de Jaume I,” *Estudis de llengua i literatura catalanes* 1 (1980): 54–55.

Ada Bruhn Hoffmeyer, however, contends that the counterweight was fixed.¹⁰⁸ The hinged-counterweight proponents can find justification for their view in Villard de Honnecourt's thirteenth-century description of a trestle-framed trebuchet (*trebucet*) that had such a counterweight.¹⁰⁹ In his reconstruction of Villard's machine, Eugene-Emmanuel Viollet-le-Duc was the first to propose that the machine designated by the term trebuchet had a hinged, rather than a fixed, counterweight. He believed that the term *mangonel* was applied to the machine with a fixed counterweight.¹¹⁰

Fixed-counterweight proponents, such as Bruhn Hoffmeyer, look to Giles of Rome (Aegidius Colonna) to support their argument. In his *De regimine principum libri tres*, produced in Italy around 1275, Giles of Rome identifies three different types of counterweight trebuchets: the machine with a fixed counterweight is called a *trabucium*, the one with a hinged counterweight a *biffa*, and the machine with both a fixed and a hinged counterweight is termed a *tripantium*.¹¹¹ His classification, however, appears to be of his own making and is not corroborated by any other source. His technical vocabulary may be relevant to Italy in the late thirteenth century, but it does not appear applicable to other regions of Europe, where no distinction is made between the trestle-framed trebuchet with a fixed counterweight and the one with a hinged counterweight.

The difficulties of interpreting written sources enhance the value of illustrated sources. Trebuchets are depicted in a large number of medieval and Renaissance manuscripts. A crude illustration of a trebuchet with a counterweight in the form of a box, indicating that it was attached by a hinge to the short arm of the beam, appears in an early thirteenth-century manuscript of Wolfram von Eschenbach's *Willehalm* and is referred to as a *tripochen*.¹¹² A later manuscript of the same text has two corrupt illustrations of a trebuchet, both of which have a hinged counterweight, and the second machine is identified as a *driboch*.¹¹³ The description accompanying the illustration of Villard de Honnecourt's trebuchet indicates that this machine also had a hinged counterweight. Francesco di Giorgio Martini, however, identifies both the trebuchet with a hinged counterweight and the one with a fixed counterweight as a *trabocchio*.¹¹⁴ The evidence from these illustrated sources offers two possible interpretations. The term *trebuchet* may have been applied to both the fixed-weight and the hinged-weight, trestle-framed gravity-powered trebuchet, or the term may have been used initially to refer to one type only—most likely the hinged-weight version—and over time its usage changed. The differences between the two types of trestle-framed counterweight trebuchets may have become in-

¹⁰⁸A. Bruhn Hoffmeyer, *Arms and Armour in Spain: A Short Survey* (Madrid, 1982), 2:102, 106, 112.

¹⁰⁹Paris, Bibliothèque nationale de France, MS fr. 19093, fol. 30r.

¹¹⁰*Dictionnaire raisonné de l'architecture du XIe au XVIe siècle*, 10 vols. (Paris, 1854–68), 5:233.

¹¹¹*De regimine principum libri tres*, quoted in R. Schneider, *Die Artillerie des Mittelalters* (Berlin, 1910), 163–64; trans. J. Hewitt, *Ancient Armour and Weapons in Europe from the Iron Period of the Northern Nations to the End of the Thirteenth Century*, 3 vols. (Oxford, 1855–60), 1:349–50.

¹¹²Munich, Bayerische Staatsbibliothek, MS cod. germ. 193 III, fol. 4v; reproduced in K. von Amira, *Die Bruchstücke der grossen Bilderhandschrift von Wolframs Willehalm* (Munich, 1921), 20 and pl. 10.

¹¹³Vienna, Österreichische Nationalbibliothek MS cod. 2670, fols. 33v and 81v; reproduced in W. von Eschenbach, *Willehalm mit der Vorgeschichte des Ulrich von dem Türlin und der Fortsetzung des Ulrich von Türlin* (Graz, 1974), fols. 33v and 81v.

¹¹⁴*Trattati di architettura ingegneria e arte militare*, ed. C. Maltese, 2 vols. (Milan, 1967), 1:272–73; fols. 60r, 61v, 62r; pls. 111, 114, 115.

creasingly blurred during the Renaissance, and this may account for a broader usage of the term trebuchet at this time.

White has suggested that the term *trebuchet* was derived from the term for a ducking-stool.¹¹⁵ It is far more likely, however, that the ducking-stool took its name from the counterweight trebuchet, rather than the other way around. Both machines are similar in design, but the siege machine was introduced earlier and probably served as the model for the ducking-stool.

INVENTION AND DIFFUSION OF THE COUNTERWEIGHT TREBUCHET

The driving force behind the development of the counterweight trebuchet was most probably the increased military activity in the eastern Mediterranean during the later part of the eleventh century and the early part of the twelfth century. This period witnessed Seljuq and crusader incursions and a Byzantine military resurgence under the Komnenoi. It also saw Armenian settlement in Cilicia and the employment of Armenians in the military services of Islamic, Byzantine, and crusader states in the region. The talent and economic resources committed to siegeworks naturally increased with rising militarization, and this condition provided a great impetus to the development of artillery. Rogers has suggested that "it is likely that more effective artillery was developed by expert siege crews in the regular employment of a commander who could afford them."¹¹⁶ If this was the case, artillery specialists employed by the Byzantine Empire may well have developed the counterweight trebuchet. Strangely, a Byzantine origin for gravity-powered artillery has never been proposed.

Ever since Gustav Köhler and Kalevero Huuri drew attention to an explicit reference to a *trabuchus* that was used in northern Italy in 1199,¹¹⁷ scholars have regarded this as evidence for the first appearance of the counterweight trebuchet in Western Europe, and many have consequently favored a European origin for the machine.¹¹⁸ Even those familiar with Byzantine source materials, such as Bruhn Hoffmeyer, Arnold W. Lawrence, and Robert W. Edwards, have overlooked the possibility that Byzantium may have developed the weapon, and have instead credited the machine to the Latin West.¹¹⁹ The favoring of the Latin West may also stem from Cahen's conflation of two distinct Arabic terms that were applied to two different types of gravity-powered artillery: the *manjanīq maghribī* (the western Islamic trebuchet) and the *manjanīq franjī* (the Frankish or European trebuchet). Cahen argued that at the end of the thirteenth century the *manjanīq maghribī* was designated by the term *manjanīq franjī*. The *manjanīq maghribī*, however, was a trestle-framed counterweight trebuchet, while the *manjanīq franjī* was the European *bricola*, a gravity-

¹¹⁵White, *Medieval Technology and Social Change*, 102; *Oxford English Dictionary*, s.v. "trebuchet."

¹¹⁶Rogers, *Latin Siege Warfare*, 247.

¹¹⁷Köhler, *Entwicklung*, 194; Huuri, "Geschützwesen," 64 n. 2, 171.

¹¹⁸White, *Medieval Technology and Social Change*, 102–3; Hill, "Trebuchets," 104; Gillmor, "Introduction," 2 n. 6; R. W. Edwards, review of C. Foss, *Survey of Medieval Castles of Anatolia*, *Speculum* 62.3 (1987): 678–79; France, *Western Warfare*, 122.

¹¹⁹A. Bruhn Hoffmeyer, "Military Equipment in the Byzantine Manuscript of Scylitzes in Biblioteca Nacional in Madrid," *Gladius* 5 (1966): 136; A. W. Lawrence, "A Skeletal History of Byzantine Fortifications," *BSA* 78 (1983): 222; Edwards, review of *Survey of Medieval Castles of Anatolia*, 678–79.

powered pole-framed trebuchet invented in the Latin West (Fig. 5). The *manjanīq firanjī* is clearly of European origin; the *manjanīq maghribī* is not.¹²⁰

Not all scholars who have dealt with the issue of the origin of the counterweight trebuchet have credited it to Western Europe. White, who earlier had favored a European origin for the machine, raised the possibility that it may have originated in Iran.¹²¹ Hill, who initially stated that the counterweight trebuchet was first developed “somewhere in Mediterranean Christendom or western Islam, towards the end of the twelfth century,” also considered a Muslim origin for the machine.¹²² Joseph Needham and Robin Yates present a variety of views on the invention of the counterweight trebuchet in *Science and Civilisation in China*. Although they contend that engineers from Arab countries introduced the machine to China, they nevertheless maintain that “the invention [of the counterweight trebuchet] was quite probably made in several places about the same time.” They propose that “one inventor may have been Chhinang Shên, the Chin commander who defended Lo-Yang against the Mongols in + 1232.” Needham and Yates also assert that the appearance of the word trebuchet in three German chronicles simultaneously in 1212 “marks the entry of the counterweight trebuchet.” They further argue that the counterweight trebuchet was “an Arab modification,” “an Arab invention,” was derived “from Arab practice,” or was “developed in West Asia.”¹²³ No scholar has suggested that the Byzantines, who were well known for their military inventiveness, developed the counterweight trebuchet.

Despite the achievements made by Byzantium in the development of artillery, misunderstandings persist about Byzantine knowledge of and use of these weapons. Carroll Gillmor states that the traction trebuchet did not appear definitely in the Byzantine Empire until 1071.¹²⁴ Edwards has explicitly denied that the counterweight trebuchet was known in twelfth-century Byzantium.¹²⁵ Clive Foss and David Winfield have suggested that the counterweight trebuchet “was introduced into Europe in the twelfth century, [was] taken up by the crusaders, and rapidly spread through the Mediterranean and Near East,” but they sidestep the question of the machine’s origin: “The history of the transmission of the trebuchet is not at all clear, and it could as well have spread from Byzantium to the West as *vice versa*.” They contend that gravity-powered ordnance came into common use during the reign of Manuel I Komnenos (1143–80), but they provide no textual evidence for this conclusion.¹²⁶

The emergence of the counterweight trebuchet is sparsely documented. A number of languages—Syriac, Arabic, Greek, and Latin—use new terminology for artillery in the twelfth century. These changes in terminology reflect changes in technology: the introduction of the counterweight trebuchet. Although the documentation for this machine during the first century of its development is random and somewhat meager, it provides dramatic evidence of cultural diffusion.

¹²⁰ Cahen, “Traité,” 158. On the nomenclature of trebuchets, see Chevedden, “Artillery of King James I.”

¹²¹ White, *Medieval Religion and Technology*, 284.

¹²² Hill, “Trebuchets,” 104; Hassan and Hill, *Islamic Technology*, 101.

¹²³ Needham and Yates, *Science and Civilisation in China*, 218, 233, 237, 238, 240, 573.

¹²⁴ Gillmor, “Traction Trebuchet,” 1–2.

¹²⁵ Edwards, review of *Survey of Medieval Castles of Anatolia*, 678.

¹²⁶ Foss and Winfield, *Byzantine Fortifications*, 48 and 181 n. 27.

Once gravity-powered artillery was invented, the dynamics of conflict and contact spurred reactive technological adaptation of this new technology over a broad area. The documentation for the counterweight trebuchet in the twelfth century comes from a wide variety of sources across a vast geographical landscape, from Mesopotamia to the central Mediterranean. The transmission of technologies and techniques in the region of western Asia and the Mediterranean world was mutual and continuous, and this was especially the case with artillery. Earlier forms of artillery had likewise experienced rapid diffusion in western Asia and the Mediterranean. Following the death of Alexander the Great, the catapult spread throughout the Mediterranean world and became common even in relatively unimportant cities.¹²⁷ The traction trebuchet first appeared in the eastern Mediterranean at the end of the sixth century and soon spread westward to Spain. In the early part of the seventh century, it caught the attention of Isidore, bishop of Seville (ca. 570–636), who referred to it as a *fundibulus* in his *Etymologiae*.¹²⁸ Shortly thereafter, the trebuchet was transmitted over a wide expanse of territory from the Atlantic to the Indus by the Islamic conquest movements. These conquests spurred innovations in military technology that led to the development of the hybrid trebuchet. By the ninth century, this machine was being used in western Asia, the Mediterranean world, and in northern Europe.¹²⁹

The rough outlines of the divergent patterns of transmission of the counterweight trebuchet can be culled from the sources. By the 1120s, gravity-powered artillery had been transmitted to Outremer and to the sultanate of the Great Seljuqs. Seljuq dependencies and local Atabeg dynasties may also have acquired the machine at this time. At mid-century, the Seljuq sultan used counterweight trebuchets to bombard the 'Abbāsid capital. In the 1130s, John II Komnenos used counterweight trebuchets with great effect in his siege campaigns in Cilicia and Syria.¹³⁰ These campaigns mark the full incorporation of the counterweight trebuchet into the Byzantine armed forces, and there is no doubt that subsequent Byzantine campaigns under John Komnenos and his successor Manuel I Komnenos (1143–80) employed the new artillery.¹³¹ If gravity-powered artillery

¹²⁷ Marsden, *Greek and Roman Artillery: Historical Development*, 73–85.

¹²⁸ Isidore equated the traction trebuchet (*fundibulus*) with the two-armed stone-projecting torsion catapult (*ballista*), the most powerful artillery piece of classical antiquity (Isidore, *Etymologiae*, 18.10). By the 4th century, this stone-projector had been replaced by the onager, and in the 6th century the onager was superseded by the traction trebuchet. By likening the *fundibulus* to the defunct *ballista* in terms of its “hurling and throwing” capabilities, Isidore was presenting new information on artillery to suit the realities of his own day. Medieval texts of Vegetius likewise present new information on artillery to conform to circumstances of a later period. The *fundibulus*, or traction trebuchet, was the principal artillery piece of Isidore's day. This term does not refer to the *fustibalus* (staff-sling), or to the onager, the one-armed torsion machine of late antiquity, as suggested by Bruhn Hoffmeyer, but to the traction trebuchet (Bruhn Hoffmeyer, *Arms and Armour in Spain: A Short Survey*, 1:95, 141). For more details on the diffusion of the traction trebuchet in the Mediterranean world, see Chevedden, “Hybrid Trebuchet,” 192–95, and Chevedden et al., “Traction Trebuchet.”

¹²⁹ For more details on the diffusion of the hybrid trebuchet in the Middle East, the Mediterranean world, and Europe, see Chevedden, “Hybrid Trebuchet,” 179–222, and Chevedden et al., “Traction Trebuchet.”

¹³⁰ See App. 1 and John Kinnamos, *Epitome rerum ab Ioanne et Alexio [sic] Comnenis gestarum*, ed. A. Meineke, CSHB (Bonn, 1836), 16–20; idem, *Deeds of John and Manuel Comnenus*, trans. C. M. Brand (New York, 1976), 21–24; Choniates, ed. van Dieten, 21–31; *O City of Byzantium*, 13–18.

¹³¹ John Kinnamos, *Epitome*, 21–22; idem, *Deeds*, 25–26; Choniates, ed. van Dieten, 32–39; *O City of Byzantium*, 19–22. Counterweight trebuchets (*helepoleis*) were most likely used in the joint Byzantine/crusader at-

was used in the Latin East in the 1120s, knowledge of it was certainly transmitted to the Latin West in rapid order. The Normans of Sicily were well acquainted with the new artillery when they attacked Alexandria in 1174 and Thessalonike in 1185, suggesting previous familiarity with the counterweight trebuchet that probably dates back to the campaigns of Roger II in southern Italy in the 1130s.¹³² The appearance of the counterweight trebuchet in northern Italy toward the end of the twelfth century also suggests an earlier acquaintance with the machine, perhaps dating back to Frederick Barbarossa's siege campaigns in Lombardy from 1155 to 1175.¹³³ Before Saladin's arrival in Egypt in 559/1164, the counterweight trebuchet must have been known in the Nile Valley, since all of Ṭarsūsī's information on the machine was gleaned from an Armenian arms manufacturer who worked under the Fāṭimids in Alexandria.¹³⁴ From the 1170s to the early 1190s, Saladin utilized gravity-powered artillery against his Muslim and crusader foes.

The great display of counterweight artillery at the siege of Acre (1189–91) was the culmination of a long process of development that had begun nearly a century earlier. Rogers regards the siege of Acre as the beginning of a transition to a new stage in the development of siege warfare in the Middle Ages. For the first time, according to Rogers, artillery was used to breach enemy fortifications, not merely to support "escalades or siege-tower assaults by harassing defenders and neutralizing their artillery," as had been the role of ordnance in earlier siege operations. "The effectiveness of artillery at Acre," Rogers claims, "anticipates developments in thirteenth-century poliorcetics, in which bombardment played an important role. . . . In this regard, the siege of Acre can be seen as ushering in the great age of pre-gunpowder artillery in the medieval west."¹³⁵ The turning point in the tactical use of artillery, however, had already taken place prior to the siege of Acre.

Eustathios's account of the siege of Thessalonike in 1185 implicitly recognizes that artillery played two principal roles in siege warfare: (1) it was used to neutralize the defense so that besiegers could fill in ditches and batter and undermine fortifications in order to facilitate a successful infantry assault; (2) it was used to breach the walls of strong-points in order to pave the way for assaulting infantry. By identifying the first tactic as the "more conventional" scheme of siege operations, Eustathios confirms what historical accounts of twelfth-century sieges indicate: that artillery was also used to breach fortifications. This new role for artillery did not begin with the introduction of the counterweight trebuchet. Powerful traction trebuchets, especially hybrid ones, also had this capability. But proficiency at breaching fortifications was greatly expanded by the employment of gravity-powered artillery. By the end of the twelfth century, the counter-

tack on Damietta in 565/1169. On this expedition, see Choniates, ed. van Dieten, 163–68; *O City of Byzantium*, 92–95; William of Tyre, *Historia*, 20.15 (pp. 929–30); idem, *Deeds Done Beyond the Sea*, 20.15 (2:364–65); Ibn Shaddād, *Nawādir*, 41–43; Ehrenkreutz, *Saladin*, 79–81; Lyons and Jackson, *Saladin*, 37; Rogers, *Latin Siege Warfare*, 84–86; R.-J. Lilie, *Byzantium and the Crusader States, 1096–1204*, trans. J. C. Morris and J. E. Ridings (Oxford, 1993), 200–202.

¹³² Rogers, *Latin Siege Warfare*, 105–20.

¹³³ Rogers, *Latin Siege Warfare*, 132–53.

¹³⁴ On Armenians in Fāṭimid Egypt, see S. B. Dadoyan, *The Fatimid Armenians: Cultural and Political Interaction in the Near East* (Leiden, 1997).

¹³⁵ Rogers, *Latin Siege Warfare*, 234–35.

weight trebuchet had reached an advanced stage of development, and defensive planning was soon to undergo revolutionary changes in order to counter the greater destructive power of the new artillery and to exploit this artillery for use in the defense of strongpoints.

The transmission of the counterweight trebuchet during the twelfth century is far easier to trace than engineering data on the machine itself. Only two twelfth-century sources provide structural details of the counterweight trebuchet: Niketas Choniates' *Historia* and Ṭarsūsī's *Tabṣīrah fī al-ḥurūb*. Both of these authors used old terminology to refer to the new machine. This indicates a general reluctance to coin new technical terms for new technology. The history of technology is rife with examples of technological changes that are not reflected by terminological ones.¹³⁶ In the twelfth century, language seldom kept pace with technological advances in the field of artillery. The references to the counterweight trebuchet that we do have from this period probably represent a mere fraction of the instances in which the machine was used. Moreover, the counterweight trebuchet was probably not recognized by new nomenclature until it had evolved to a certain stage of development and was employed on a regular basis. One would scarcely expect a distinct nomenclature for the machine to develop when it was still new and unfamiliar. Thus, the first occurrence of a new name for the counterweight trebuchet probably does not signal the date of its introduction. The counterweight trebuchet doubtless emerged prior to the use of new terms to denote it.

If so, the siege of Nicaea in 1097 may mark the introduction of the counterweight trebuchet. Yet, the new terms for this machine, which refer to "big," "great," and "huge" or "frightful" pieces of artillery, all disappear during the thirteenth century and are replaced by a different set of names for gravity-powered ordnance. What does this terminological shift signify? Are we right to assume that the terms that arise in the twelfth century denote a new technological reality (the counterweight trebuchet), given the dramatic changes in nomenclature that occur in the thirteenth century? Perhaps the shift to new terms in the thirteenth century signifies the actual emergence of gravity-powered artillery, while the transition in terms a century earlier may reflect only an evolution to more powerful versions of existing artillery devices. An understanding of the real nature of the terminological shift can be achieved by examining the terms.

WHAT'S IN A NAME?

During the thirteenth century, the counterweight trebuchet was designated by three new terms in Arabic: the *manjanīq maghribī* or *manjanīq gharbī* (the western Islamic trebuchet), the *manjanīq qarābughrā* (the "Black Camel" trebuchet), and the *manjanīq franjī* or *manjanīq ifranjī* (the Frankish or European trebuchet). The *manjanīq maghribī* and *manjanīq qarābughrā* were both trestle-framed machines. The *manjanīq maghribī* generally launched stone-shot,¹³⁷ while the *manjanīq qarābughrā* was specifically designed to launch

¹³⁶On problems in terminology, with particular reference to artillery, see J. Needham, *Science and Civilization in China*, vol. 5, *Chemistry and Chemical Technology*, pt. 7, *Military Technology: The Gunpowder Epic* (Cambridge, 1986), 11–12, 130, 131, 248, 310, 311, 373.

¹³⁷The historical sources mention the *manjanīq maghribī* or *manjanīq gharbī* (the Western Islamic trebuchet) as being employed in the sieges of the following cities and castles: Damietta in 615/1218 (Abū Bakr ibn 'Abd

bolts.¹³⁸ The *manjanīq firanjī* was a large pole-framed machine, obviously derived from Western Europe as its name indicates, and known in Latin sources as the *bricola* (Fig. 5).¹³⁹ In the Latin West, the term *trebuchet* was joined by a legion of new terms after 1200: *blida* or *blide* (also *bleide*, *bidda*, *pleiden*, *pleyde*, *plaid*, *plijde* and *pleite*), *biffa* (also *biffe* and

Allāh ibn Aybak al-Dawādārī, known as Ibn al-Dawādārī, *Kanz al-durar wa-jāmi' al-ghurar*, vol. 7, *al-Durr al-maṭlūb fī akhbār mulūk banī Ayyūb*, ed. Sa'īd 'Ashūr [Cairo, 1972], 195; Ibn al-Muqaffa', *History of the Patriarchs*, 3.2:129 [Arabic text], 218 [trans.]; Oliver of Paderborn, *The Capture of Damietta*, trans. J. J. Gavigan [Philadelphia, 1948], 25, 26, 34, 44, 54, 56), Kakhtā in 623/1226 (Nāṣir al-Dīn al-Ḥusayn ibn Muḥammad Ibn Bībī, *Histoire des Seldjoudes d'Asie Mineure d'après l'abrégé du Seldjouknameh d'Ibn-Bibi*, ed. T. Houtsma [Leiden, 1902], 118; and idem, *Die Seldschukengeschichte des Ibn Bibi*, trans. H. W. Duda [Copenhagen, 1959], 122), Baalbek in 627/1229 (Muḥammad ibn Ibrāhīm ibn Muḥammad al-Anṣārī, *Ta'rikh dawlat al-akrād wa-al-atrāk*, Istanbul, Süleymaniye Library, Hekimoğlu Ali Paşa Collection, MS 695, fol. 124v), Shayzar in 630/1232–33 (Ibn Wāṣil, *Mufarrij*, 5:65; Ibn al-'Adīm, *Zubdah*, 3:214), Ḥarrān and Edessa in 633/1236 (Ibn al-Muqaffa', *History of the Patriarchs*, 4.1, 70 [Arabic text], 147 [trans.]; Anṣārī, *Ta'rikh*, fols. 138v–139r), Homs in the winter of 646/1248–49 (Ibn Wāṣil, *Mufarrij al-kurūb fī akhbār Banī Ayyūb*, Paris, Bibliothèque nationale, fonds arabe, MS 1703, fol. 60v–61r; Anṣārī, *Ta'rikh*, fol. 165r), Caesarea in 663/1265 (Muḥyī al-Dīn Ibn 'Abd al-Zāhir, *al-Rawḍ al-zāhir fī sirat al-Malik al-Zāhir*, ed. 'Abd al-'Azīz al-Khuwayṭir [Riyadh, 1976], 230; Nāṣir al-Dīn Muḥammad ibn 'Abd al-Raḥīm Ibn al-Furāt, *Ayyubids, Mamlukes and Crusaders: Selections from the "Ta'rikh al-Duwal wa'l-Mulūk"*, ed. and trans. U. Lyons and M. C. Lyons, 2 vols. [Cambridge, 1971], 1:85; 2:69), and Ṣafad in 664/1266 (Ibn 'Abd al-Zāhir, *Rawḍ*, 257–58; Ibn al-Furāt, *Ayyubids, Mamlukes and Crusaders*, 1:116–17; 2:91–92). For illustrations of this siege machine, see Chevedden, "Artillery of King James I," figs. 8, 9, 13.

¹³⁸This siege machine is identified by Ibn Urunbughā al-Zaradkāsh as the "Black Camel" (*qarābughrā*) trebuchet (*Kitāb al-anīq fī al-manājanīq*, ed. Nabīl Muḥammad 'Abd al-'Azīz Aḥmad [Cairo, 1981], 26; *ibid.*, ed. Iḥsān Hindī [Aleppo, 1985], 45), but all Arabic historical sources, save for Nasawī's *Sīrat Jalāl al-Dīn*, which was produced in a Persian cultural milieu, designate it as the "Black Bull" (*qarābughā*) trebuchet, a corruption of the original term (see D. Ayalon, "Ḥiṣār," *EP*, 3:473). Arabic historical chronicles cite this weapon as being used in the sieges of the following cities and castles: Akhlāt in 626/1229 (Muḥammad ibn Aḥmad al-Nasawī, *Sīrat Jalāl al-Dīn*, ed. Ḥāfiẓ Ḥamdī [Cairo, 1953], 303), Homs in the winter of 646/1248–49 (Ibn Wāṣil, *Mufarrij* [Bibliothèque nationale, MS 1703], fol. 61r), Marqab in 684/1285 (Muḥyī al-Dīn Ibn 'Abd al-Zāhir, *Tashrif al-ayyām wa-al-'usūr fī sirat al-Malik al-Mansūr*, ed. Murād Kāmil and Muḥammad 'Alī al-Najjār [Cairo, 1961], 78), Tripoli in 688/1289 (Abū Bakr ibn 'Abd Allāh ibn Aybak al-Dawādārī, known as Ibn al-Dawādārī, *Kanz al-durar wa-jāmi' al-ghurar*, vol. 8, *al-Durrah al-zakīyah fī akhbār al-Dawlah al-Turkīyah*, ed. U. Haarmann [Cairo, 1971], 283; Quṭb al-Dīn Mūsā ibn Muḥammad al-Yūnīnī, *Dhayl mir'āt al-zamān fī ta'rikh al-a'yān*, Istanbul, Topkapı Sarayı Müzesi Kütüphanesi, Ahmet III Collection, MS 2907/I.3, fol. 254r; Nāṣir al-Dīn Muḥammad ibn 'Abd al-Raḥīm Ibn al-Furāt, *Ta'rikh Ibn al-Furāt*, ed. C. K. Zurayk and N. Izzedin, [Beirut, 1936–42], 8:80), Acre in 690/1291 (Shams al-Dīn al-Jazarī, *Ḥawādith al-zamān wa-anbā'uḥu wa-wafayāt al-akābir wa-al-a'yān min abnā'ihi* [Jawāhir al-sulūk], Paris, Bibliothèque nationale, fonds arabe, MS 6739, fol. 24v; idem, *La Chronique de Damas d'al-Jazarī* [Années 689–698 H.], summary translation of *Jawāhir al-sulūk* by J. Sauvaget [Paris, 1949], 5; Badr al-Dīn al-'Aynī, *Iqd al-jumān fī ta'rikh ahl al-zamān*, Istanbul, Topkapı Sarayı Müzesi Kütüphanesi, Ahmet III Collection, MS 2912/4, fol. 144v; Quṭb al-Dīn Mūsā ibn Muḥammad al-Yūnīnī, *Dhayl mir'āt al-zamān*, ed. A. Melkonian, *Die Jahre 1287–1291 in der Chronik al-Yūnīs* [Freiburg im Breisgau, 1975], 86 [Arabic text]; Ibn al-Furāt, *Ta'rikh*, 8:112), and Qal'at al-Rūm in 691/1292 (Ibn al-Dawādārī, *Kanz*, 8:333; Mufaḍḍal Ibn Abū al-Faḍā'il, *al-Nahj al-sadīd wa-al-durr al-farīd fīmā ba'da ta'rikh Ibn al-'Amīd*, ed. and trans. E. Blochet, *Histoire des sultans mamlouks*, PO [Paris, 1919–28], 14:553; K. V. Zetterstéen, ed., *Beiträge zur Geschichte der Mamlükensultane in den Jahren 690–741 der Hira, nach arabischen Handschriften* [Leiden, 1919], 16; Shihāb al-Dīn al-Nuwayrī, *Nihāyat al-arab fī funūn al-adab*, quoted in Aḥmad ibn 'Alī al-Maqrīzī, *Kitāb al-sulūk li-ma'rīfat duwal al-mulūk*, 4 vols. [Cairo, 1934–73], 1.3:778 n. 2; Ibn al-Furāt, *Ta'rikh*, 8:136). For an illustration of this siege machine, see Chevedden, "Artillery of King James I," fig. 10.

¹³⁹The *manjanīq firanjī* or *manjanīq ifranjī* (the Frankish or European trebuchet) is first cited in Arabic historical sources at the beginning of the Mamlūk period and is mentioned as being employed in the sieges of the following cities and castles: Caesarea in 663/1265 (Ibn 'Abd al-Zāhir, *Rawḍ*, 230; Ibn al-Furāt, *Ayyubids, Mamlukes and Crusaders*, 1:85; 2:69), al-Bīrah in 674/1275 ('Izz al-Dīn Muḥammad Ibn Shaddād, *Ta'rikh al-Malik al-Zāhir*, ed. Aḥmad Huṭayṭ [Wiesbaden, 1983], 125; Quṭb al-Dīn Mūsā ibn Muḥammad al-Yūnīnī, *Dhayl mir'āt al-zamān*, 4 vols. [Hyderabad, 1954–61], 3:114; Nāṣir al-Dīn Shāfi' ibn 'Alī al-'Asqalānī, *Ḥusn al-*

buffa), *bricola* (also *bricole*, *briccola*, *brigola*, and *brigolette*), *carabaga* (also *caraboha*, *carabouha*, *carabaccani*, and *carabachani*), *couillart* (also *coillard*, *coyllar*, and *collarde*), *tribulus*, *tribuculus*, and *tripantium*, to mention the most prominent.¹⁴⁰ Scholars have been baffled by this profusion of terms, calling the terminology “confused,” “contradictory,” “uncertain,” “vague and imprecise,” “inconsistent,” exhibiting “no uniformity,” “very complicated,” and “all but impenetrable.”¹⁴¹ Summing up the views of many historians, Rogers asserts that the set of terms used for medieval artillery in the Latin West is characterized by an absence of clarity and coherence.¹⁴²

Although the technical vocabulary of medieval artillery is complicated and somewhat elusive, clarification can be achieved. Today, a resolution of the terminological confusion is hampered mainly by a proclivity for rehashing old arguments and a reluctance to bring a wider range of historical evidence to bear on the question. The difficulties of understanding the nature of the terminological shift, as well as the terms themselves, are reduced by an awareness of three important factors: (1) the terms reflect a diversification of the counterweight trebuchet into different forms; (2) the terms embody regional variations in terminology; and (3) the terms represent changes in nomenclature over a period of time. Had gravity-powered artillery not diversified into different forms, there would have been no need for new terms. The old terms—such as *manjanīq* in Arabic, *helepolis*

manāqib al-sirrīyah al-muntaza’ah min al-sīrah al-Zāhirīyah, ed. ‘Abd al-‘Azīz al-Khuwaytir [Riyadh, 1976], 158), Marqab in 684/1285 (Ibn ‘Abd al-Zāhir, *Tashrif*, 78), Ṣahyūn in 685/1286 (Ibn ‘Abd al-Zāhir, *Tashrif*, 149–50), Tripoli in 688/1289 (Ibn al-Dawādārī, *Kanz*, 8:283; Yūnīnī, *Dhayl* [Istanbul, Topkapı Sarayı Müzesi Kütüphanesi, Ahmet III Collection, MS 2907/1.3], fol. 254r; Ibn al-Furāt, *Ta’rīkh*, 8:80), Acre in 690/1291 (Jazarī, *Hawādīth al-zamān*, fol. 24v; idem, *Chronique de Damas*, 5; Badr al-Dīn al-‘Aynī, *Iqd al-jumān fī ta’rīkh ahl al-zamān*, Istanbul, Topkapı Sarayı Müzesi Kütüphanesi, Ahmet III Collection, MS 2912/4, fol. 144v; Yūnīnī, *Dhayl* [ed. Melkonian], 86 [Arabic text]; Ibn al-Furāt, *Ta’rīkh*, 8:112), and Qal’at al-Rūm in 691/1292 (Ibn al-Dawādārī, *Kanz*, 8:333; Zetterstéen, *Beiträge*, 16; Jazarī, *Chronique de Damas*, 16; Ibn Abū al-Faḍāl, *Nahj*, 14:553; Nuwayrī, *Nihāyah*, quoted in Ibn Abū al-Faḍāl, *Nahj*, 14:553 n. 1, and Maqrīzī, *Sulūk* 1.3:778 n. 2; Ibn al-Furāt, *Ta’rīkh*, 8:136). For illustrations of this siege machine, see Chevedden, “Artillery of King James I,” fig. 11; Ibn Urunbughā, *Anīq*, ed. Aḥmad, 47, 51; idem, *Anīq*, ed. Ḥindī, 97–98. In his account of the siege of Hsiang-Yang by the Mongols in the late 13th century, the Chinese historian Chêng Ssu-Hsiao refers to “Muslim trebuchets” (*hui-hui phao*) used against the city: “The design of the Muslim trebuchets came originally from the Muslim countries, and they were more powerful than ordinary trebuchets. In the case of the largest ones, the wooden framework stood above a hole in the ground. The projectiles were several feet in diameter, and when they fell to the earth they made a hole three or four feet deep. When [the artillerists] wanted to hurl them to a great range, they added weight [to the counterpoise] and set it further back [on the arm]; when they needed only a shorter distance, they set it forward, nearer [the fulcrum]” (Needham and Yates, *Science and Civilisation in China*, 5.6:221). The largest trebuchets at the siege of Hsiang-Yang appear to have been *bricolas* since the framework of the *bricola* was commonly mounted in a single hole in the ground.

¹⁴⁰ On the terminology of the counterweight trebuchet, see Huuri, “Geschützwesens,” 63–67, 132, 171–74, 187–89, 213–15; Chevedden, “Artillery of King James I,” 61–63, 71–76, 84, 86, 87, 91, figs. 7–15; idem, “Hybrid Trebuchet,” 180, 181, 183, 184–86, 189, 190, 192, 197, 200, 201, 206–9, 211, 212, 214–16, figs. 2, 4, 5.

¹⁴¹ These remarks are from the following studies cited in the order listed: Finó, *Forteresses*, 150; idem, “Machines de jet médiévales,” 25; H.-P. Eydoux, *Les châteaux de soleil: forteresses et guerres des croisés* (Paris, 1982), 279; R. A. Brown, *English Castles* (London, 1976), 175; France, *Western Warfare*, 118; France, *Victory in the East*, 48; Bruhn Hoffmeyer, *Arms and Armour in Spain: A Short Survey*, 2:104; Hacker, “Greek Catapults and Catapult Technology,” 41. For other comments on the question of nomenclature, see L. Monreal y Tejada, *Ingeniería militar en las crónicas catalanas*, Discurso de Ingreso en la Real Academia de Buenas Letras (Barcelona, 1971), 18.

¹⁴² Rogers, *Latin Siege Warfare*, 258.

or *petrobolos* in Greek, and *petraria* in Latin—may have taken on a broader meaning as they had done in the past, and the new terms that referred to “big,” “great,” and “huge” or “frightful” machines may have faded away. Since the term *trebuchet* arises long after the introduction of the counterweight machine, its usage probably does not coincide with the first appearance of this weapon in Europe. Rather, it probably reflects the beginning of the process of diversification of gravity-powered artillery into multiple forms in the Latin West.

The process of diversification of gravity-powered artillery in the Latin West was most likely underway by the 1180s. During this decade, the term *trebuchet* appears for the first time, and “newly invented heavy artillery [*helepoleis*]” are cited at the siege of Thessalonike. These “newly invented” machines were not likely to have been trestle-framed counterweight trebuchets, but gravity-powered artillery considerably different from the trestle-framed engine. Eustathios identifies two types of capital ordnance used by the Normans at Thessalonike: “newly invented” heavy artillery employed on the western side of the city and two other large trebuchets on the eastern side of the city, which were not described as newly made or created or put to use for the first time. He regarded the pair of machines on the eastern side of the city as conventional in every way, save for the great size and power of one of them, a trebuchet so immense and powerful that it was called “The Daughter of the Earthquake.” The two conventional pieces of artillery were doubtless trestle-framed counterweight trebuchets, the earliest form of gravity powered artillery.

By the 1180s, the trestle-framed counterweight trebuchet was no longer either a novelty or a rarity, and thus Eustathios does not identify the two large “rock-throwers” on the eastern side of the city as new machines. His “newly invented” *helepoleis* on the western side of the city must have represented an innovation in the design of the counterweight trebuchet to warrant this characterization. If so, these machines were most probably European *bricolas*. The design of the *bricola* was noticeably different from that of the trestle-framed trebuchet (Fig. 5). The massive pole that was used for its frame and the two hinged-counterweights that hung from its bifurcated throwing arm gave it a unique appearance that justified its name, the “two-testicle machine” (from Latin *bi-coleus*). The innovative and distinctive design of the *bricola* explains why such artillery would have attracted the attention of Eustathios and would have prompted him to single it out from the other artillery used by the Normans. The new artillery brought against Thessalonike, like so many new technologies, apparently had design or performance problems during its first employment. The newly invented trebuchets performed poorly, Eustathios tells us, because their large size made them difficult to manage.

Historical sources indicate that the *bricola* first emerged in the lands of the western Mediterranean basin. The earliest mention of the *bricola* in an historical source records its use in 1238 by Emperor Frederick II of Hohenstaufen at the siege of Brescia. During the 1240s, *bricolas* appear in a number of sieges in Italy. In 1242 Frederick II sent *bricolas* and other siege machines to the Levant, and soon thereafter the Muslims incorporated this versatile piece of artillery into their siege arsenal, calling it the Frankish or European trebuchet (*manjanīq ifranjī* or *manjanīq firanjī*). The *bricola* went on to become the most widely used piece of naval ordnance in the Mediterranean. It was mounted on the poops

of ships and was used to bombard coastal cities and fortresses. The early history of the *bricola* makes a Norman origin for this machine quite likely. At Thessalonike, Eustathios recognized its distinctive design as an innovation in the design of heavy artillery.¹⁴³

BYZANTIUM AND THE COUNTERWEIGHT TREBUCHET

If the process of diversification of the counterweight trebuchet began during the 1180s, development of this machine was probably underway much earlier. Although it is impossible to determine with certitude when gravity-powered artillery was invented, due to the tenuous nature of the evidence, a late eleventh-century dating appears to be a reasonable estimate. Such a dating for the emergence of the counterweight trebuchet favors a Byzantine origin. The Byzantines were leaders and innovators in the field of artillery. The first Mediterranean civilization to utilize the trebuchet was Byzantium. The Byzantines not only improved upon the artillery technology that they had acquired from Asia, but they also found new tactical uses for it. They adopted the “hand-trebuchet,” which they dubbed the *cheiromangana*, and employed this weapon in field battles. Byzantine engineers brought heavy artillery to the peak of its development during the eleventh century. They produced the two most powerful trebuchets that are recorded in the historical sources for that century, and at Nicaea they startled everyone by constructing trebuchets fashioned according to entirely new design principles.¹⁴⁴

Economic and political factors also suggest a Byzantine origin for the machine. When Alexios I Komnenos came to the throne in 1081, the Byzantine state was in a desperate

¹⁴³For a discussion of the *bricola*, see Chevedden, “Artillery of King James I,” 72–76. On Frederick II’s siege of Brescia, see *Annales placentini gibellini*, MGH, SS, ed. G. H. Pertz (Hanover, 1863), 18:479; T. C. van Cleve, *The Emperor Frederick II of Hohenstaufen, Immutator Mundi* (Oxford, 1972), 415–16; and D. Abulafia, *Frederick II, a Medieval Emperor* (London, 1988), 308–9. For other sieges in Italy during the early 1240s that featured the *bricola*, see *Annali genovesi di Caffaro e de’ suoi continuatori*, ed. L. T. Belgrano and C. Imperiale di Sant’Angelo, 4 vols. (Rome, 1890–1929), 3:100, 120, 121; Chevedden, “Artillery of King James I,” 74–75. On Frederick II’s shipment of *bricolas* to the Levant in 1242, see *Annali genovesi*, 3:128: “Et cum inimici mari et terra cum machinis, prederiis [= *petrariis*], bricolis, scalis et aliis hedificiis eorum infortunio ad locum Levanti pervenissent.”

¹⁴⁴Needham and Yates claim that the “hand-trebuchet” was invented by a Chinese military engineer named Liu Yung-Hsi in 1002 (Needham and Yates, *Science and Civilisation in China*, 5.6:214). Byzantine sources, however, mention the “hand-trebuchet” (*cheiromangana*) in the 10th century. The *Praecepta militaria* of the emperor Nikephoros II Phokas (963–969), dating from ca. 965, recommends the use of “hand-trebuchets” in field battles to break up enemy formations. The *Taktika* of Nikephoros Ouranos, dating from ca. 1000, also recommends the use of “hand-trebuchets” in field operations. The *Anonymus De obsidione toleranda* includes the “hand-trebuchet” in a list of artillery (ed. H. van den Berg [Leiden, 1947], 48, lines 3–4: τετραρέας, μαγγανικά, καὶ τὰς λεγομένας ἡλακάτας, καὶ χειρομάγγανα . . .). On the Byzantine *cheiromangana*, see McGeer, *Sowing the Dragon’s Teeth*, 21, 65, 97. McGeer incorrectly identifies the *cheiromangana* as a portable arrow launcher, similar to a crossbow, that was mounted on a stand. The Byzantines probably came to realize the usefulness of the trebuchet in field operations after their defeat in the battle of Anzen in 223/838. In this battle, the Byzantine army under Emperor Theophilus faced ‘Abbāsīd forces under the caliph’s general Afshīn. On the afternoon of 22 July, Turkish archers isolated and surrounded the emperor and a band of 2,000 Khurramī refugees from al-Jibāl (modern Luristān) and were closing in for the kill when a rainstorm rendered their bows useless. The Muslims quickly brought up traction trebuchets and hurled stones on the Byzantine forces, which then dispersed in panic (*Chronique de Michel le Syrien*, ed. and trans. J.-B. Chabot, 4 vols. [Paris, 1905], 3:95, 4:535; Bar Hebraeus, *Chronography*, ed. Bedjan, 149; W. Treadgold, *The Byzantine Revival, 780–842* [Stanford, 1988], 300). An illustration in the *Cantigas de Santa Maria*, dating from ca. 1280, depicts a “hand-trebuchet” being operated alongside a counterweight trebuchet in the siege of a city (Chevedden, “Artillery of James I,” fig. 12; Chevedden, “Hybrid Trebuchet,” 213, fig. 4).

situation. The Seljuqs were in occupation of most of Anatolia, the Pechenegs were menacing the Danubian provinces, and Constantinople was under threat of a Norman attack. By 1095 Alexios had overcome the Normans, defeated the Pechenegs, and was about to begin his reconquest of Asia Minor. As the economic and political fortunes of the Byzantine Empire revived under Alexios, greater resources became available to the army. These resources were used to attract a wide range of talent to advance Byzantine military ventures, and fresh talent was doubtless used to develop and exploit new ideas relating to mechanized siegecraft. Alexios's project to reconquer Anatolia would have provided a tremendous incentive for the development of artillery, since the peninsula could only be won back by utilizing a powerful siege-train well equipped with ordnance. Alexios had both the foresight and the finances to hire the technicians and establish the workshops to build batteries of heavy artillery for his campaign of reconquest. The Byzantines under the Komnenoi built upon a military tradition that encouraged innovation, and their creative efforts must have concentrated on the development of heavy artillery, a major pursuit of the Byzantine army throughout the eleventh century. The machine that marked the high point in the development of mechanical warfare—the counter-weight trebuchet—probably emerged under Byzantine auspices, and the invention “which amazed everyone” at Nicaea in 1097 may well have been the first gravity-powered piece of artillery.¹⁴⁵

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¹⁴⁵On Alexios I Komnenos's attempt to reconquer Anatolia, see H. Ahrweiler, *Byzance et la mer: la marine de guerre, la politique et les institutions maritimes de Byzance aux VIIe–XVe siècles* (Paris, 1966), 175–225; C. Cahen, *Pre-Ottoman Turkey: A General Survey of the Material and Spiritual Culture and History, c. 1071–1330*, trans. J. Jones-Williams (New York, 1968), 72–96; M. Whittow, “How the East Was Lost: The Background to the Komnenian Reconquista,” in Mullett and Smythe, *Alexios I Komnenos* (as above, note 43), 1:55–67; M. Mullett, “1098 and All That: Theophylact Bishop of Semnea and the Alexian Reconquest of Anatolia,” *Peritia* 10 (1996): 237–52. For a discussion of the development of the Komnenian army during this period, see Birkmeier, “Development of the Komnenian Army.” For political and economic developments of this period, see F. Chalandon, *Essai sur le règne d'Alexius Ier Comnène (1081–1118)* (Paris, 1900); P. Magdalino, *The Empire of Manuel I Komnenos, 1143–1180* (Cambridge, 1993); C. M. Brand, *Byzantium Confronts the West, 1180–1204* (Cambridge, Mass., 1968); A. Harvey, *Economic Expansion in the Byzantine Empire, 900–1200* (Cambridge, 1990).

Appendix 1

References to Counterweight Trebuchets Employed during the Twelfth Century

Abbreviations

- A.2 Anon. *Anonymi auctoris Chronicon ad annum Christi 1234 pertinens*. Ed. J.-B. Chabot. CSCO, ser. 3, vol. 37, Scriptores Syri 15. Paris, 1916.
- A.2 [E] ———. “The First and Second Crusade from an Anonymous Syriac Chronicle.” Trans. A. S. Tritton, with notes by H. A. R. Gibb. *JRAS* (1933): 69–101, 273–305.
- A.2 [F] ———. *Anonymi auctoris Chronicon ad annum Christi 1234 pertinens*. Vol. 2. Trans. A. Abouna, CSCO 354, Scriptores Syri 154. Paris, 1974.
- AS Abū Shāmāh, ‘Abd al-Raḥmān ibn Ismā‘īl. *Kitāb al-rawḍatayn fī akhbār al-dawlatayn*. Vol. 1, pt. 2. Ed. M. H. M. Aḥmad and M. M. Ziyādah. Cairo, 1962.
- B, *Zubdah* al-Bundārī, Faṭḥ ibn ‘Alī. *Zubdat al-nuṣrah wa-nukhbat al-‘uṣrah*. Ed. M. T. Houtsma. Recueil de textes relatifs à l’histoire des Seljoucides 2. Leiden, 1889.
- BH Bar Hebraeus, Gregorius. *Makhtebhānūth Zabhnē*. Ed. P. Bedjan. Paris, 1890.
- BH [E] Bar Hebraeus, Gregorius. *The Chronography of Gregory Abū’l Faraj, the Son of Aaron, the Hebrew Physician, Commonly Known as Bar Hebraeus*. Vol. 1. Trans. E. A. W. Budge. London, 1932.
- C Choniates, Niketas. *Historia*. Ed. J. van Dieten. CFHB 11. Berlin, 1975.
- C [E] ———. *O City of Byzantium, Annals of Niketas Choniates*. Trans. H. J. Magoulias. Detroit, 1984.
- Cod. Ecel. Codex diplomaticus Ecelinianus. In Giambatista Verci, *Storia degli Ecelini*. 3 vols. Bassano, 1779.
- E Eustathios, Archbishop of Thessalonike. *The Capture of Thessaloniki*. Trans. J. R. Melville Jones. Canberra, 1987.
- GC Codagnello, Giovanni. *Iohannis Codagnelli Annales Placentini*. Ed. O. Holder-Egger. MGH, *ScriptRerGerm*. Hanover-Leipzig, 1901.
- IA Ibn al-‘Adīm, Kamāl al-Dīn ‘Umar ibn Aḥmad. *Zubdat al-ḥalab min ta’rīkh Ḥalab*. 3 vols. Ed. Sāmī al-Dahhān. Damascus, 1951–68.
- ID, *Barq* al-Kātib al-Isfahānī, ‘Imād al-Dīn Muḥammad ibn Muḥammad. *Al-Barq al-Shāmī*. Vol. 5. Ed. Fāliḥ Ḥusayn. Amman, 1987.
- ID, *Faṭḥ* ———. *Kitāb al-fayḥ al-qussī fī al-faṭḥ al-Qudsī*. Ed. Carlo de Landberg. Leiden, 1888.
- ID, *Sanā* ———. *Sanā al-Barq al-Shāmī, 562/1166–583/1187*. Abridged by al-Faṭḥ ibn ‘Alī al-Bundārī. Ed. Faṭḥiyah al-Nabarāwī. Cairo, 1979.

- IS Ibn Shaddād, Bahā' al-Dīn Yūsuf ibn Rāfi'. *Al-Nawādir al-sultānīyah wa-al-maḥāsīn al-Yūsufīyah, aw, Sirat Ṣalāḥ al-Dīn*. Ed. Jamāl al-Dīn al-Shayyāl. Cairo, 1964.
- IW Ibn Wāṣil, Jamāl al-Dīn Muḥammad ibn Sālim. *Mufarrij al-kurūb fī akhbār Banī Ayyūb*. Vols. 1–3. Ed. Jamāl al-Dīn al-Shayyāl. Cairo, 1953–60; Vols. 4–5. Ed. S. A. F. 'Āshūr and H. M. Rabī'. Cairo, 1972–77.
- U Usāmah ibn Munqidh. *Kitāb al-i'tibār*. Ed. Qāsim al-Sāmarrā'i. Riyadh, 1987.

<i>Date</i>	<i>Site</i>	<i>Besieged by</i>	<i>Term</i>	<i>Source</i>
518/1124	Tyre	Crusaders	<i>manganīqē rawrbē</i> (great trebuchets)	A.2, 94 A.2 [F], 71 A.2 [E], 95
519/1125	'Azāz	Aq Sunqur al-Bursuqī, Seljuq governor of Mosul, and Ṭughtigin, Börid Atabeg of Damascus	<i>manganīqē rawrbē</i> (great trebuchets)	A.2, 98 A.2 [F], 73 A.2 [E], 97
532/1138	Shayzar	John II Komnenos	<i>majānīq hā'ilah</i> (huge trebuchets) <i>majānīq 'izām</i> (great trebuchets)	U, 134 IA, 2: 268
551–552/1157	Baghdad	Sultan Muḥammad II	<i>manjanīqayn 'azīmāyn</i> (two great trebuchets)	B, <i>Zubdah</i> , 249
1165	Zevgminon	Andronikos I Komnenos	πετροβόλους μηχανάς (<i>petrobolous mēkhanas</i>) (rock-throwing engines)	C, 134 C [E], 76
569–570/1174	Alexandria	Normans	<i>majānīq kibār</i> (big trebuchets)	ID, <i>Fath</i> , 227–28 ID, <i>Sanā</i> , 78 AS, 598–600 IW, 2: 11–16
572/1176	Maṣyāf	Saladin	<i>al-manjanīqāt al-kibār</i> <i>al-majānīq al-kibār</i> (big trebuchets)	ID, <i>Sanā</i> , 105 AS, 669–70 IW, 2: 47–48
579/1183	Āmid	Saladin	<i>manjanīq hā'il</i> (huge trebuchet), called <i>al-Mufattish</i> (The Examiner)	ID, <i>Barq</i> , 85
580/1184	Kerak	Saladin	<i>al-manjanīqāt al-kibār</i> (big trebuchets)	ID, <i>Sanā</i> , 241
1184	Nicaea	Andronikos I Komnenos	ἐλέπολις (<i>helepolis</i>) (city-taker)	C, 282 C [E], 156

<i>Date</i>	<i>Site</i>	<i>Besieged by</i>	<i>Term</i>	<i>Source</i>
1185	Thessalonike	Normans	ἐλεπόλεις (<i>helepoleis</i>) (city-takers) σεισμοῦ θυγάτηρ (<i>seismou thugatēr</i>), (The Daughter of the Earthquake); also known as μεγάλη μηχανή (<i>megalē mēkhanē</i>) (great siege-engine), τὴν μητέρα (<i>tēn mētera</i>) (Their Mother), and γραῖα (<i>graia</i>) (The Old Woman)	E, 72–73 E, 74–75; 96–99
583/1187	Jerusalem	Saladin	<i>manganīqē rawrbē</i> (great trebuchets)	BH, 375 BH [E], 325
583/1187	Tyre	Saladin	<i>al-majānīq al-kibār</i> (big trebuchets)	ID, <i>Fath</i> , 73–86, 110
1189	Vicenza		<i>trabuchellus</i>	Cod. Ecel., 97
586/1190	Acre	Crusaders	<i>manjanīqayn kabīrayn</i> (two big trebuchets) of Henry of Champagne, one costing 1,500 di- nars, destroyed by sally in force; <i>manjanīqāt</i> <i>hā'ilah</i> (two huge trebu- chets) destroyed by fire-arrows shot from a large crossbow	ID, <i>Fath</i> , 282 IS, 136 AS, 2: 162 IW, 2: 335
1199	Castelnuovo Bocca d'Adda	Cremonans	<i>trabuchus</i>	GC, 25

Appendix 2

Ṭarsūsī's Description of the Counterweight Trebuchet

Ṭarsūsī's account of a counterweight trebuchet comprises not one but two descriptions. The first is merely a summary of the longer description that follows it. Both may have been composed by Ṭarsūsī from information provided by Ibn al-Abraqī, or the first may be a short paraphrase of the original description received from Ibn al-Abraqī, which then follows it. By calling his counterweight machine a "Persian" trebuchet (*manjanīq fārisī*), Ṭarsūsī does not mean to imply that it is of Iranian origin, as Cahen and White supposed (Cahen, "Traité," 158; White, *Medieval Religion and Technology*, 284). He is simply instructing the reader to take a traction trebuchet of the same design as one he has previously identified as a "Persian" or "Turkish" trebuchet (*manjanīq al-fārisī wa-huwa al-turkī*) and to make certain modifications to it in order to produce a counterweight machine. Here is his description:

[B133v/A100r] *A Description of a Persian Trebuchet, Made for Me by Shaykh Abū al-Ḥasan ibn al-Abraqī al-Iskandarānī, with a Throwing Power of Fifty Men More or Less*

At the bedplate of its framework is a bow of a crossbow. The entire device [trebuchet and crossbow] is operated by a single man who discharges it [the double-purpose machine]. When the man hauls down the beam, the hemp cords, which are pulled by it [the beam], cause the bowstring to reach its catch. The man secures the pouch [of the sling] to a ring fixed to a base which holds the beam. He takes the [cross]bow and shoots it. Then he releases the beam, and the stone is thereby discharged.

[B134r] Take a Persian trebuchet [*manjanīq fārisī*] and set it up to shoot. Dig a hole next to its framework to a depth equal to the length of the hemp cords on the beam. Then take a net of close-meshed hemp and place at its ends three strong hemp cords [A100v], long enough to reach from the end of the beam, where the axle is, to the bottom of the hole. At the extremity of the beam there should be an iron ring to which the cords of the net are attached. The quantity of stones placed in the net should be equal to the power of the men who [would be required to] pull the beam [of a traction trebuchet]. At the extremity of the beam, next to the cord of the pouch [of the sling], there should be a system of pulleys placed in a pulley block that hangs from the beam.

After the man hauls down [the beam] [B134v], he places the stone in the pouch [of the sling] and hangs its cord on the hook [*or* the style] fixed to the end of the beam. The man [B135r] is able to pull the net [i.e., the counterweight] by pulling the end of the beam, since it swings back like a steelyard. After he hauls down [the beam], he secures [B134v] the pouch [of the sling], with an iron hook placed at its [the pouch's] lower end, to a ring fixed to a base which holds the power [*qūwah*, i.e., the weight] of the net [i.e., the counterweight] [B135r]. The bow of the crossbow

is placed at the bottom of the base of the trebuchet in two iron hooks that hold it [B134v]. Its [bow]string, with the cords which raise the net [i.e., the counterweight], is placed in a drawing-claw fixed to the cords, so when the cords rise with the net [i.e., the counterweight] [B135r], they pull the bowstring and convey it to the catch on its stock.

After the man secures the pouch [of the sling] to the base, he takes the [cross]bow and places [B134v] the bolt on its course and shoots it. Then he returns immediately to the pouch [of the sling] and discharges it all by himself [B135r]. When the net [i.e., the counterweight] pulls the beam, it brings it back to its upright position; and this is better than the traction[-power] of men, because it [i.e., the net or counterweight] pulls with a constant force [B134v], [whereas] men differ in their pulling force. Here is an illustration of it [pictured on fols. B134v-135r/A101v-102r; see Fig. 1].